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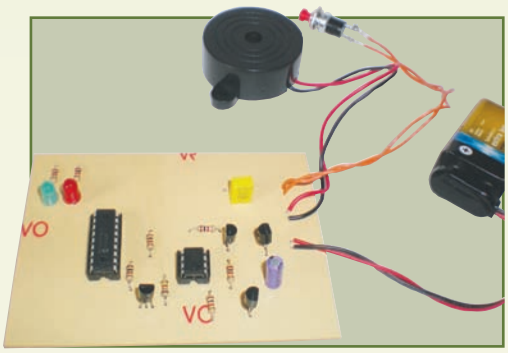

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Our August 2010 issue will be published on Thursday 8 July 2010, see page 72 for details.

AUTOMOTIVE & POWER KITS FOR
ELECTRONIC ENTHUSIASTS

SPEEDO CORRECTOR MKII KIT

KC-5435 £16.00 plus postage & packing
This kit readjusts the speedometer signal up or down from 0% to 99% of the original signal. This upgraded model enables automatic input setup selection and indicates when the input signal is being received. Kit supplied with PCB with overlay and all electronic components.

Recommended box UB5 use HB-6013 £1.25

10A 12VDC MOTOR SPEED CONTROLLER KIT

KC-5225 £7.25 plus postage & packing
Ideal for controlling 12VDC motors in cars such as fuel injection pumps, water/air intercoolers and water injection systems. Use it for headlight dimming or for running 12VDC motors in 24V vehicles. The circuit incorporates a soft start feature to reduce inrush currents, especially on 12V incandescent lamps. Kit includes PCB and all electronic components.

CAR HEADLIGHT REMINDER KIT

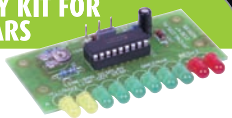
KC-5317 £8.25 plus postage & packing
Features include a modulated alarm, ignition and lights monitoring, optional door switch detection, time-out alarm and a short delay before the alarm sounds. 12VDC kit includes quality solder masked PCB with overlay, case with screen printed lid and all electronic components.

DIGITAL TACHOMETER KIT

KC-5290 £19.75 plus postage & packing
Housed neatly in a small jiffy box (83 x 54 x 31mm) to mount nicely on your dashboard, it features 10 LED bargraph with optional dot or bar mode (showing 8-independent rpm thresholds), calibration options for 1-12 cylinder 4-stroke or 1-6 cylinder 2-stroke engines, anti-flickering and automatic night-time display dimming. This kit can also be combined with our rev limiter KC-5265, to perform engine limiting. Kit includes case with silk-screened panel, PCBs, pre-programmed PIC micro, 7-segment displays, red acrylic, hook-up wire and all electronic components.

MIXTURE DISPLAY KIT FOR FUEL INJECTED CARS

KC-5195 £5.00 plus postage & packing
Also known as an EGO (exhaust, gas, oxygen) monitor, this simple kit allows you to monitor your car's fuel mixtures. Use it as a tuning tool to help in vehicle modification or simply to see the behaviour of the engine control module. LEDs indicate whether mixtures are rich, lean or normal. PCB, LEDs and components supplied. Thousands sold!



HIGH PERFORMANCE TIMER KIT

KC-5379 £12.50 plus postage & packing
A sophisticated timer adaptable for two types of uses. The first is 'one shot' operation, which can be used to keep electric windows active, or a thermo fan running for a period after ignition is switched off etc. The second is a 'pulse' type operation, which can be used to squirt water spray for 1 second every 9 seconds. The uses are endless, with time adjustable from 0.1 sec to 16.5 mins. Kit supplied with PCB and all electronic components.

FUEL KITS

Wideband Fuel Mixture Controller Kit

KC-5486 £23.25 plus postage & packing
Partner to the Wideband Sensor Display Kit KC-5485 (below) and intended to be used with a Bosch wideband LSU4.2 oxygen sensor to accurately measure air/fuel ratios over a wide range from rich to lean. It can be used for precise engine tuning and can be a permanent installation in the car or a temporary connection to the exhaust tailpipe. This 12VDC kit comes with PCB and all electronic components including programmed PIC, and case with screen printed lid.

- PCB: 112 x 87mm

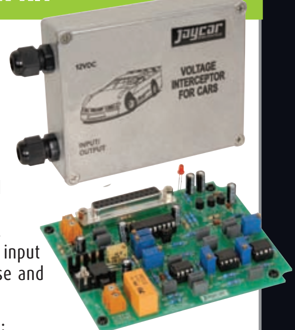
Fuel/Air Mixture Display Kit

KC-5485 £17.50 plus postage & packing
Displays your car's air-fuel ratio as you drive. Designed to monitor a wideband oxygen sensor and its associated wideband controller. Alternatively it can be used to monitor a narrowband oxygen sensor or for monitoring other types of engine sensors.

- 12VDC
- Double-sided plated PCB
- Programmed PIC
- Electronic components
- Case with machined and screen printed lid

VOLTAGE MODIFIER KIT

KC-5490 £23.25 plus postage & packing
Restore correct air/fuel ratios after engine modifications, prevent engine boost cuts; or alter sensor signals for improved drivability. Requires hand controller for programming, RS232 cable and a suitable input signal. Kit includes PCB, case and electronic components.

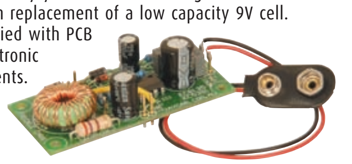


Recommended with this kit:
Hand Controller Cat. KC-5386 £19.75
RS232 Cable Cat. WC-7502 £4.00

POWER KITS

3V to 9V DC-DC Converter Kit

KC-5391 £4.75 plus postage & packing
Allows you to use regular Ni-Cd or Ni-MH 1.2V cells, or Alkaline 1.5V cells for 9V applications. Use low cost, high capacity rechargeable cells - imagine the extra capacity you would have using two 9000mAh D cells in replacement of a low capacity 9V cell. Kit supplied with PCB and electronic components.



DC Relay Switch Kit

KC-5434 £5.00 plus postage & packing
An extremely useful and versatile kit that enables you to use a tiny trigger current as low as 400μA at 12V to switch up to 30A at 50VDC. The kit includes PCB with overlay and all electronic components with clear English instructions.

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KIT OF THE MONTH

SD/MMC Card Webserver In a Box

KC-5489 £26.25 plus postage & packing
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Addressing the future

Just as we are getting used to using the Internet for everything from news and shopping to esoteric articles on alien abduction conspiracies, it seems we are about to run out of addresses. It's not that people can't dream up new 'www.thisismyuniqueaddress.com' destinations; no, the problem lies in the unsustainable rate at which we are devouring the limited amount of 'number' addresses that lie behind the Internet's basic structure.

All devices connected to the public Internet are given a unique number known as an Internet Protocol (IP) address. These consist of four numbers (in the range 0-255) separated by full stops, and which look like 127.0.0.1.

The 127.0.0.1-style system, known as IPv4, can supply around four billion addresses, which sounds a lot until you consider the huge and growing number of home and office computers, networks, mobile phones and all the other digital systems that need to be uniquely addressed. ISPs have delayed the address drought with techniques such as dynamic addressing, but the end is nigh for IPv4, with some commentators speculating that September next year will see the system serving up the last set of IPv4 addresses.

Fortunately, there is a plan B, called IPv6 (IPv5 was a dead end it seems). IPv6 will enable a jaw-dropping 340 trillion trillion trillion addresses. The good news is that most computer operating system suppliers have made their software IPv6 compliant (since XP for MS Windows and 10.3/Panther for Mac OSX aficionados). The bad news is that not all hardware is compliant, with devices such as Skype phones or printers listed as potential trouble spots. Big system changes are never problem free, so now might be a good time to check if your system is going to be affected.

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NEWS

A roundup of the latest Everyday News from the world of electronics

The dock is dead, long live wireless! By Barry Fox

According to Joseph Liow, VP Personal Digital Entertainment Products at Californian company Creative Labs, 'Docking speakers are dead. Say goodbye to them. Wireless speakers are in.'

Creative is hoping to redefine wireless connection with a two-pronged strategy; simplify Bluetooth pairing and use a different audio coding system to improve sound quality and reduce latency, the delay usually caused by Bluetooth coding and decoding.

Conventional Bluetooth wireless links, as now standard with portable music players and cellphones, can be tricky to set up. The user must set the devices to search for each other, then enter a pass code to authorise temporary connection and push keys to confirm permanent connection. Different devices may use different codes (such as 0000, 1234 or 12345), which adds to the difficulty; sometimes the codes must be entered very rapidly to work; and some devices just stubbornly refuse to pair.

The mandatory standard for transmitting stereo by Bluetooth is the A2DP codec (Advanced Audio Distribution Profile) which has limited audio quality and delays the sound, which spoils lip sync for TV and video sound. Creative is using the apt-x coding system, developed around 1990 by Belfast-based company apt-x for professional use, and now permitted as an optional standard for Bluetooth. Audio is transparently delivered over the Bluetooth link, whether it is stored uncompressed or in a compression format (MP3, AAC, FLAC). Low latency means the signal is not noticeably delayed.

Creative is now launching a range of wireless speaker kits worldwide, which use a Bluetooth transmitter dongle that plugs into an iPod (except the Shuffle), iPhone or iPad, or any laptop or netbook USB socket that supports Bluetooth A2DP. The dongle then transmits an apt-x stream at 768kbps to a matching receiver in the speaker. The source player controls the speaker volume.

'It's super easy and super hassle-free' said Creative's Marcom Director Mac Aw Kum Weng, before proving the point at a London demonstration by plugging a dongle into a new iPad and getting near instantaneous connection to one of Creative's new speakers.

Creative is launching four speaker systems between now and July, ranging in price from around £50 to £250. Dongles cost £35. The speakers can also be used with portables that do not have a standard iPod 30-pin socket or USB port. But the connection is then in ordinary Bluetooth A2DP mode, with conventional pairing.

New technology used to unearth crucial information about historic photographs

A wealth of vital information about the early days of photography could be unearthed by a computer program which mimics human decision-making.

De Montfort University Leicester (DMU) has amassed a collection of hundreds of exhibition catalogues containing invaluable information about individual photographs, but the images themselves are missing as the catalogues were printed before the technology existed to reproduce pictures alongside the descriptions.

DMU's Professor Stephen Brown and Professor Robert John are investigating a form of computational intelligence known as fuzzy logic to see if it is possible to match these catalogue entries with photographs in online collections owned by museums.

Professor Brown, of the Faculty of Art and Design, said: 'Many of the photographs in question appear to have survived and are increasingly accessible online through museum and gallery websites. However, precise associations between particular exhibits and images are not always clear.'

Software using fuzzy logic is able to suggest possible connections based on vague information. It mimics the human approach to problem solving, but arrives at a decision much more quickly than people do.

Uniting the catalogue records with their original photographs would provide researchers with an important primary resource.

Professor Stephen Brown said: 'Photographic history research is important in a range of areas of study, including social, political, economical, scientific and architectural studies.

'For example, Sir Benjamin Stone, who was MP for Birmingham, was a keen photographer and collector. He was able to photograph many leading scientists, politicians and dignitaries and significant historical and royal occasions – such as Queen Victoria's funeral.

Professor Robert John, Head of the Centre for Computational Intelligence and a world-leading expert in fuzzy logic, said: 'Using fuzzy logic will allow photographs to be analysed and compared with the catalogue information very quickly.

'The benefits of this type of technology are that it can make decisions much more quickly than humans and it is not restricted to a simple 'match'/'no match' answer.'

In straightforward cases, photographs and catalogue information could be matched by name, title and other details, however, the majority of cases are more complicated.

Professor Brown added: 'Some of the records in the catalogues are rather vague. For instance, you might have the name, but the only address given is 'London'. If a photograph is then found with the same name, but the photographer's address is given as 'Blackheath' then is that the same person? It could well be, but further examination is needed.

'We could get a group of photographic experts to examine the images and the catalogue entries in order to match them up, but it would take years and be prohibitively expensive.'

Researchers will first carry out an exploratory study to investigate the potential of using fuzzy logic to match images with the descriptions in the catalogues.

If it proves to be a success, researchers hope it will be extended to a full project which will see online photo collections from museums and galleries around the world scanned for possible matches.

DMU has two online collections of catalogue records from photographic exhibitions:

- Photographic Exhibitions in Britain 1839 to 1865 – see **http://peib.dmu.ac.uk**
- Exhibitions of the Royal Photographic Society 1870 to 1915 – see **http://erps.dmu.ac.uk**

Could you be an unusual suspect?

Following on from last month's item about file sharing, the consumer magazine *Which?* has issued advice on insecure home networks.

'Make sure you secure the wireless network on your internet connection', says *Which? Computing*, 'or you could end up as one of the 'unusual suspects' – people who have been wrongly accused of illegal file sharing'.

Thousands of letters have been sent by law firms to people who, the lawyers claim, have illegally uploaded their clients' copyrighted material onto the internet. These include 80-year-olds accused of sharing techno music and young mums accused of uploading gay pornography.

Which? has been highly critical of law firms who employ this practice and is campaigning so that the volume litigation approach to file sharing is stopped. The consumer champion believes that legal action should not be used as a first response, but reserved for the most serious offenders.

In the meantime, an estimated 7.8 million UK households have unsecured wireless networks. Anyone with a WiFi enabled device could piggyback onto this connection without the account holder's knowledge. Any illegal activity could see the finger of blame pointed squarely at the owner of the wireless network.

Which? Computing thinks it's a good idea that internet users secure their connection, even though they are not obliged to, and has published advice on how to achieve this.

Peter Vicary-Smith, chief executive, *Which?*, says:

'*Which?* continues to battle law firms that threaten innocent consumers, but people also need to take steps to protect themselves. We urge anyone with a wireless network to secure it immediately. If they don't, they could end up in the awful position of being accused of a crime they haven't committed and, in some cases, wouldn't even know how to commit.'

Samsung's newest baby

Samsung Electronics has announced the launch of the world's smallest monochrome laser printer. The ML-1665 fits easily into a small business or home office environment and its environmentally-friendly features make this compact printer perfect for environmentally aware students, home office and small office users.

At just 341 x 224 x 184mm (13.4in × 8.8in × 7.2in) it may be tiny, but it packs a punch, with up to 1200 × 600dpi effective output and up to 16ppm in A4.

Car hacking – a real threat

Yes, you read that correctly, 'car hacking', not 'car jacking'. A report, *Experimental Security Analysis of a Modern Automobile*, from the The Center for Automotive Embedded Systems Security (a collaboration between researchers at the University of California San Diego and the University of Washington) has expressed concern about the cyber security of modern cars.

The report states, 'Modern automobiles are no longer mere mechanical devices; they are pervasively monitored and controlled by dozens of digital computers coordinated via internal vehicular networks. While this transformation has driven major advancements in efficiency and safety, it has also introduced a range of new potential risks.'

The authors continue, '… we experimentally evaluated these issues on a modern automobile and demonstrated the fragility of the underlying system structure. We demonstrated that an attacker who is able to infiltrate virtually any electronic control unit (ECU) can leverage this ability to completely circumvent a broad array of safety-critical systems. Over a range of experiments, both in the lab and in road tests, we demonstrated the ability to adversarially control a wide range of automotive functions and completely ignore driver input — including disabling the brakes, selectively braking individual wheels on demand, stopping the engine, and so on.

'We found that it is possible to bypass rudimentary network security protections within the car, such as maliciously bridging between our car's two internal subnets.' The authors also highlighted 'composite attacks that leverage individual weaknesses, including an attack that embeds malicious code in a car's telematics unit and that will completely erase any evidence of its presence after a crash.'

Fortunately, the report's authors give advice on 'addressing these vulnerabilities while considering the existing automotive ecosystem.'

HP builds a 'memristor'

Researchers at HP Labs have solved a decades-old mystery by proving the existence of a fourth basic element in integrated circuits that could make it possible to develop computers that turn on and off like an electric light.

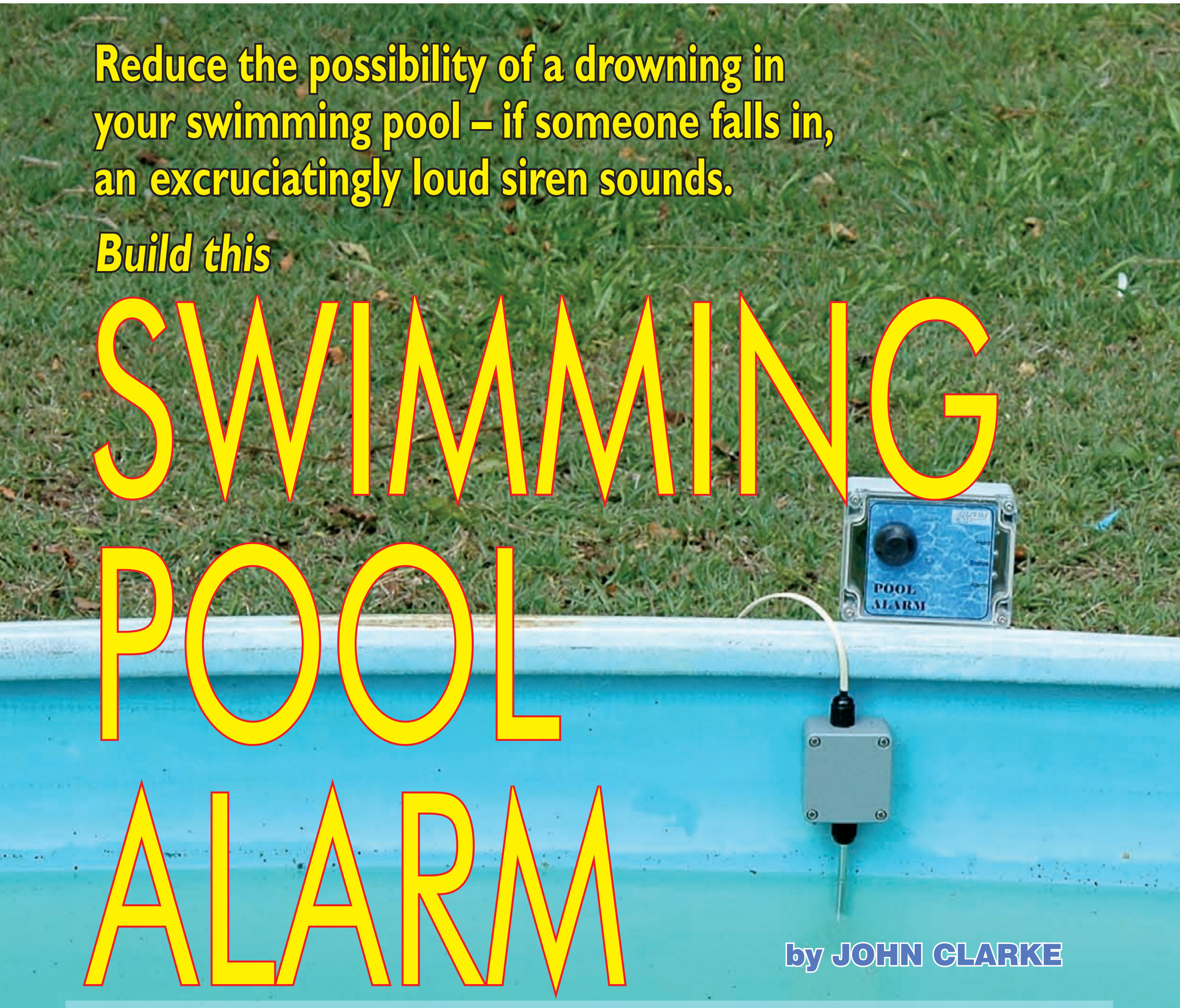
The memristor – short for memory resistor – could make it possible to develop far more energy-efficient computing systems with memories that retain information even after the power is off, so there's no wait for the system to boot up after turning the computer on. It may even be possible to create systems with some of the pattern-matching abilities of the human brain.

Leon Chua, who first described and named the memristor, argued that it should be included with the resistor, capacitor and inductor as the fourth fundamental circuit element, since it has properties that cannot be duplicated by any combination of the other three.

Nature by Numbers

True enough, this is not about electronics, but I am quite certain that anyone who is interested in how the world works – and that must mean *EPE* readers – will be captivated by this short film on YouTube.

Nature by Numbers examines the occurrence of the Fibonacci sequence and Golden Ratio as fundamental mathematical building blocks in nature. Beautifully crafted and free to view, this lovely little film is available at: **www.youtube.com/watch?v=kkGeOWYOFoA**. Well worth four minutes of your time.



Reduce the possibility of a drowning in your swimming pool – if someone falls in, an excruciatingly loud siren sounds.

Build this

SWIMMING POOL ALARM

by JOHN CLARKE

SWIMMING POOLS are dangerous places, especially for toddlers – as the table above right chillingly shows. And the pool in your own backyard is certainly not exempt; in fact, statistics show that's where more than half of all toddler drownings occur.

Even while taking the photographs for this article, with mother millimetres out of shot and grandfather (Ross) in front taking the picture, 14-month-old Keira (who cannot swim) needed no prompting to attempt to get in the pool – not once, but again and again.

While swimming pools these days must be fenced off, there is always the possibility that a toddler will find a way in. That can be as simple as a gate not latching properly or a determined youngster climbing the fence.

So while fences may appear to make a pool secure, they are never foolproof. A secondary defence, one that warns if someone falls into the pool, can literally be the difference between life and death.

A way to add secondary safety is with a pool alarm. The type of pool alarm described here monitors the amount of pool water movement and sounds an alarm when this exceeds a preset level.

Of course, wind can also create movement in the pool water – after all, that's what makes waves in the ocean. The last thing you want is false alarms – remember the boy who cried 'wolf!'?

The Pool Alarm can be set to a level which ignores typical wind movement but screams its head off when that level is exceeded – ie, someone falls in.

Here's why your pool needs this swimming pool alarm – some sobering facts about toddler (0-5yrs) drownings*:

41% occur in <u>swimming pools</u> (virtually all in backyard pools)
60% occur in the <u>toddler's own home</u>
70% occur in <u>metropolitan areas</u>
40% occur <u>during school hours</u> (38% <u>3-6pm</u> and 20% <u>6-9pm)</u>
66% are boys
60% are either one or two years old
* From NSW Water Safety Task Force Report, 2002

FEATURES....

- Monitors wave height caused by any disturbance in the pool
- Adjustable quiescent and alarm wave levels
- Adjustable alarm period
- Pushbutton switch for Hold/Monitor modes
  – Hold mode gives visual but silent alarm (for testing and attended pool use)
  – Monitor mode for visual and audible alarm (for unoccupied pool use)
- Automatic return to Monitor mode after pool water settles
- Adjustable return to Monitor period
- Optional Set-to-Hold mode with pool turbulence preventing false alarms
- Indications of Hold, Status and Alarm conditions
- Weatherproof housing
- Can drive two alarm sirens
- Plugpack-powered
- Suits all pools where the top water level is below the pool edge

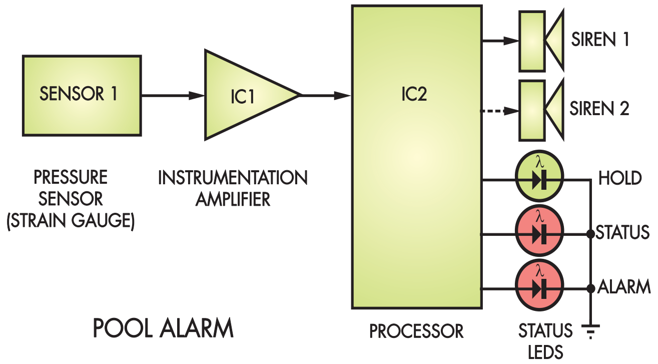


Fig.1: the Pool Alarm in block diagram form. Pressure variations due to changes in the water level are detected by Sensor 1. Its weak output is amplified and then processed by the PIC microcontroller, which controls the alarms and drives the status LEDs.

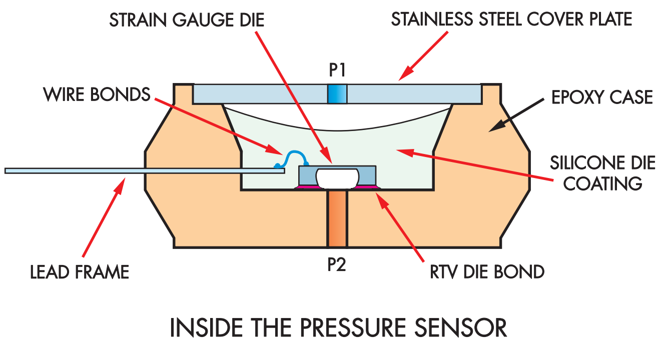


Fig.2: this cross-section diagram shows the internal structure of the MPX-2010DP pressure sensor. The strain gauge varies its resistance according to the applied load. P1 and P2 are the two port openings.

How it works

OK, let's see how it works. Fig.1 shows the block diagram of the Pool Alarm. It uses a pressure sensor to detect sudden increases in water depth, as happens when an object falls into the pool creating waves.

The unit is built in two sections, each in a weatherproof box. One houses the sensor, while a second, which we have dubbed the Pool Alarm box, houses the PIC-controlled alarm circuit. The two are connected via a 4-way cable.

While our photo shows the alarm box on the side of the pool, this would not be a typical installation. Rather, the Pool Alarm box would normally be located close to the filter box (where mains power is available) or more likely in the house, if the pool is reasonably close. The cable can be run underground across to the pool sensor box.

Inside the sensor box is a pressure sensor. This measures the water pressure variations in the pool due to waves, and sets off an alarm if these variations reach a preset level. The sensor box has a thin tube emerging from it. The box is placed so that the probe tip is about 60mm to 90mm under water. This sensor box can be secured to a pool ladder or fixed to the side of the pool, as we have shown in our photos.

The pool alarm is plugpack-powered, so it needs to be located near to the mains. Complete safety from the mains power is provided first by the isolation given by the plugpack and second, by the fact that there is no electrical contact with the water itself.

Additional features

Our Pool Alarm has several features worth noting. Most prominent on the main alarm box is a weatherproof pushbutton 'Hold' switch. This is used to set the operating mode of the alarm. When powered up, the alarm is initially set to its normal monitor mode, where it checks for pool wave movement. It takes about 10 seconds after power up to begin monitoring, and during this time, the green 'Hold' LED remains lit. After the 10 seconds, the LED flashes briefly every 1.5 seconds, indicating that the alarm is in the monitor mode.

If the alarm senses that the pool wave movement is sufficient, it will sound the alarm. The alarm period can be varied from between zero and five minutes, with typical settings around the 30s to 3-minute range. During the alarm period, an Alarm LED flashes on and off at five times per second.

The alarm siren can be stopped at any time by pressing the Hold switch. This will also stop the Alarm LED flashing. The Hold LED will also stop flashing, but unlike the Alarm LED, it will remain constantly on. The Pool Alarm is now in the Hold mode, where the alarm will not sound.

However, the Alarm LED will flash whenever wave movement is above the alarm threshold. The hold mode is used when the pool is in use.

Wave movement

The degree of wave movement required to set off the alarm can be calibrated to suit your pool. This is done by dropping a weighted bucket into the pool (simulating a small child falling into the water) and pressing the alarm level switch (on the PC board). The Pool Alarm will monitor the wave movement over a 10s period, and set up the level required for the alarm. During this calibration period, a 'Status' LED will be lit.

A second quiescent level can also be calibrated into the Pool Alarm. This level is the wave movement within the pool when no-one is in it, but with a light breeze blowing and perhaps the filter running (normal filter running should not trigger the alarm).

In practice, the level is calibrated under these conditions (ie, when a reasonable wind is blowing) by pressing the Quiescent Level calibration switch. The alarm then monitors wave movement for 10 seconds and stores the level. During this calibration period, the Status LED is lit.

Quiescent level calibration allows the Pool Alarm to provide extra features. First, it allows the mode to return from the Hold to the monitor mode automatically. So when the pool is being used, the Hold switch is pressed to set the Pool Alarm to the Hold mode so that the alarm will not sound. However, during this time, the alarm continues to monitor the wave movement. Typically,

Here are the three main elements of the Pool Alarm. At left, actually shown upside-down, is the sensor with the open-ended tube emerging from a cable gland. Centre is the alarm proper, housed in a waterproof box so it can be mounted outside near the pool if you wish. At right is a commercial strobe/siren, which is triggered when a large enough wave occurs in the pool, ie, when someone falls in!

during pool use, the wave movement will continue to be over the quiescent level and the alarm will remain in the Hold mode.

When the pool is not in use, wave movement within the pool will settle to below the quiescent level. In this case, the alarm will change from Hold mode to Monitor mode, after a preset period of 'no pool' activity. The period of inactivity can be adjusted to allow for the way the pool is used.

If the pool is often vacant for a short time before it is used again, the period can be made sufficiently long to prevent the return to Monitor happening in that time period. The adjustment range is from 1.25 to 75 minutes. One setting prevents the monitor return function.

The change from Hold to Monitor and from Monitor to Hold can also be toggled with the Hold pushbutton switch. The Hold LED then flashes for Monitor and is continuously lit for the Hold mode.

During the monitoring mode, windy conditions may cause wave movement that could exceed the quiescent level but may be below the alarm level. The Pool Alarm has an option that can return it to the Hold mode if the quiescent level is exceeded for 30 seconds without the alarm level being exceeded. This feature is included to prevent false alarms from the siren in windy weather. The Pool Alarm will then return to the monitoring mode after the wave movement has reduced to below the quiescent level.

Should the alarm sound and time out before the Hold switch is pressed, the alarm will return to Hold after the alarm period expires. The 'return to hold' option can be enabled or disabled with a jumper pin selection.

Just which option you select depends on your pool and whether it is subject to windy conditions. Protected pools may not need the 'return-to-hold' feature. This is a compromise between preventing false alarms and providing continuous pool protection.

Pressure sensor

An air-pressure sensor, the MPX-2010DP manufactured by Freescale Semiconductor, is used to measure wave movement. Its internal arrangement is shown in Fig.2. The sensor comprises a strain gauge that provides a resistance variation with applied load. In this case, the load is the air pressure exerted on the gauge due to a tube inserted into the pool.

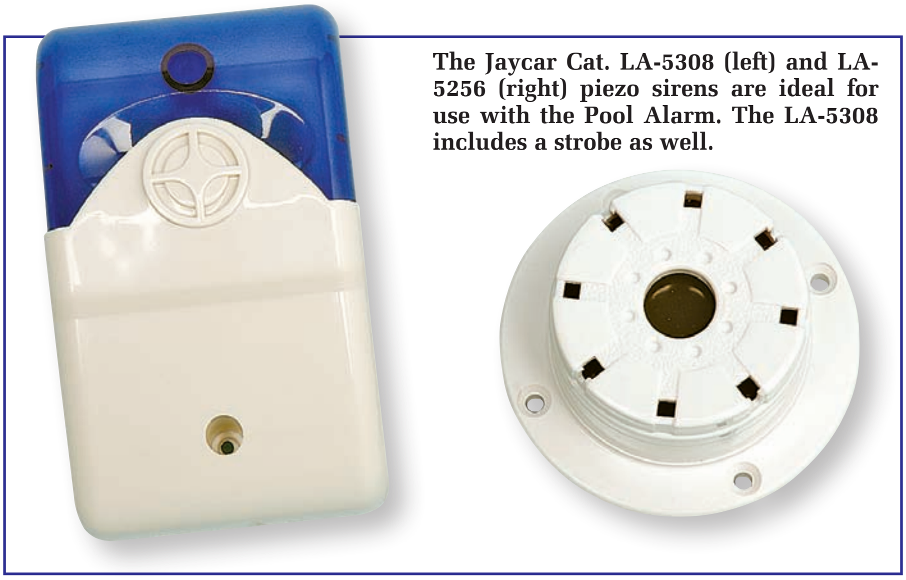
The sensor is called a differential type because it measures the difference in pressure between one port and the other. For our application, we use Port 1, which has a silicone gel protective layer to prevent moisture affecting the strain gauge element. Port 2 is left disconnected and is vented to the inside of the enclosure.

By the way, this is the same pressure sensor as used in the *PIC-Based Water Tank Level Meter*, described in the last three issues.

Circuit description

The full circuit of the Pool Alarm is shown in Fig.2, and comprises the pressure sensor, an instrumentation amplifier and a PIC microcontroller, plus associated switches, LEDs and other components.

Sensor 1 has differential outputs at pins 2 and 4. With the same pressure at both ports, pins 2 and 4 are nominally at the same voltage; ie, 2.5V. If the pressure at port 1 increases compared to port 2, pin 2 rises and pin 4 falls. The change in voltage is quite small – around 1mV for a 1kPa pressure difference. However, the actual voltage change with typical wave movement is only around 200μV,



The Jaycar Cat. LA-5308 (left) and LA-5256 (right) piezo sirens are ideal for use with the Pool Alarm. The LA-5308 includes a strobe as well.

so we need to amplify this signal using instrumentation amplifier IC1.

Since we are concerned with wave movements (ie, pressure variations) rather than the absolute pressure levels, the output from the sensor is AC-coupled via 1μF non-polarised capacitors to op amps IC1a and IC1b. The non-inverting inputs of IC1a and IC1b (pins 3 and 5 respectively) are biased via 470kΩ resistors to a +2.5V reference, derived using two 2.2kΩ resistors and a 100μF capacitor.

IC1a and IC1b are set up as non-inverting amplifiers with 39kΩ feedback resistors and a single 10Ω resistor between their inverting inputs. A 470pF capacitor across the 39kΩ resistors rolls off signals above about 8.7kHz, and this prevents possible oscillation. The gains of IC1a and IC1b are each 1 + 39kΩ/10Ω, or close enough to 3900.

The outputs of IC1a and IC1b are summed in differential amplifier IC1c, which effectively adds the two outputs together. IC1c's gain is 2 × 27kΩ/22kΩ, or 2.45 (for the two outputs), so the overall gain is 3900 × 2.45 or 9555.

Rain filtering

IC1c's output is filtered using a 2.2kΩ resistor and a 10μF capacitor to remove high-frequency signals above 7.2Hz. This prevents alarm triggering due to the detection of rain falling on the pool. IC1c also shifts the DC level of the output signal. This is done by feeding it with an offset voltage from IC1d, via the 27kΩ resistor from pin 14.

IC1d obtains its reference voltage from a pulse width modulated (PWM) signal from PIC micro IC2. This signal swings from 0V to 5V at a frequency of 490Hz, and has a duty cycle of about 50%. The PWM signal is filtered using a 220kΩ resistor and a 10μF capacitor, and is fed to pin 12 of IC1d.

The PWM signal is adjusted automatically during calibration so that IC1c's output is at 2.5V when there is no signal from Sensor 1.

Microcontroller functions

The PIC16F88-I/P microcontroller (IC2) processes the signal from IC1c and drives the alarm and the Hold, Status and Alarm LEDs. IC2 also monitors inputs at RB1, RB2 and RB3 for the switches, the linking options at RA2, the RB4 to RB7 inputs for BCD1 and the voltage at the wiper of trimpot VR1.

Output RA7 drives the flashing Alarm LED, while output RA6 drives transistors Q1 and Q2, which are the siren drivers.

Trimpot VR1 is monitored by the AN4 input and its wiper voltage is converted to a digital value from 0 to 255 for its 0V to 5V range, to give a timeout period in minutes. This value is placed in a counter that is decremented every 1.18s until it reaches zero and the alarm goes off.

Hold switch S1 connects to the RB3 input, which is normally held high (+5V) via an internal pull-up resistor. When S1 closes, IC2 responds by altering the mode from Hold to Monitor, or from Monitor to Hold. Output RA1 drives the Hold LED via a 1kΩ resistor.

Output RA0 drives Status LED 2 via a 1kΩ resistor. LED2 lights during the quiescent set and Alarm set procedures. If LED2 is flashing, it indicates levels that are over the quiescent setting.

Switches S2 (Quiescent Set) and S3 (Alarm Set) are monitored by the RB1 and RB2 inputs. Pressing S2 or S3 starts the program in IC2. This monitors the AN3 input and calculates the voltage range encountered for a period of 10s.

It does this by monitoring the AN3 input every 100ms and storing the level in memory. After sampling for 10s, it finds the minimum and maximum values and subtracts the minimum from the maximum to derive the span range. This value is then multiplied by 95% for the Alarm level, and 105% for the Quiescent level. The lower alarm level provides for a small amount of leeway in pool movement to sound the alarm.

The higher quiescent setting of 105% is so that the quiescent level for the pool will normally be less than this. The resulting values are then used to check for quiescent or alarm levels at the AN3 input.

Whether or not to return to Hold from monitoring is selected with the linking at input RA2. RA2 is pulled high with the link in LK2 position and low with the link in LK1.

Rotary switch BCD1 selects the monitor return period. When BCD1 is in position 0, all the switches are open and the RB4 to RB7 inputs are pulled high via internal pull-up resistors. This setting is for a 'no-return to monitoring' from hold. Other settings of the BCD switch will pull at least one of the RB4-RB7 lines to ground via its common pin, and select a time period as shown in Table 3.

PWM signal

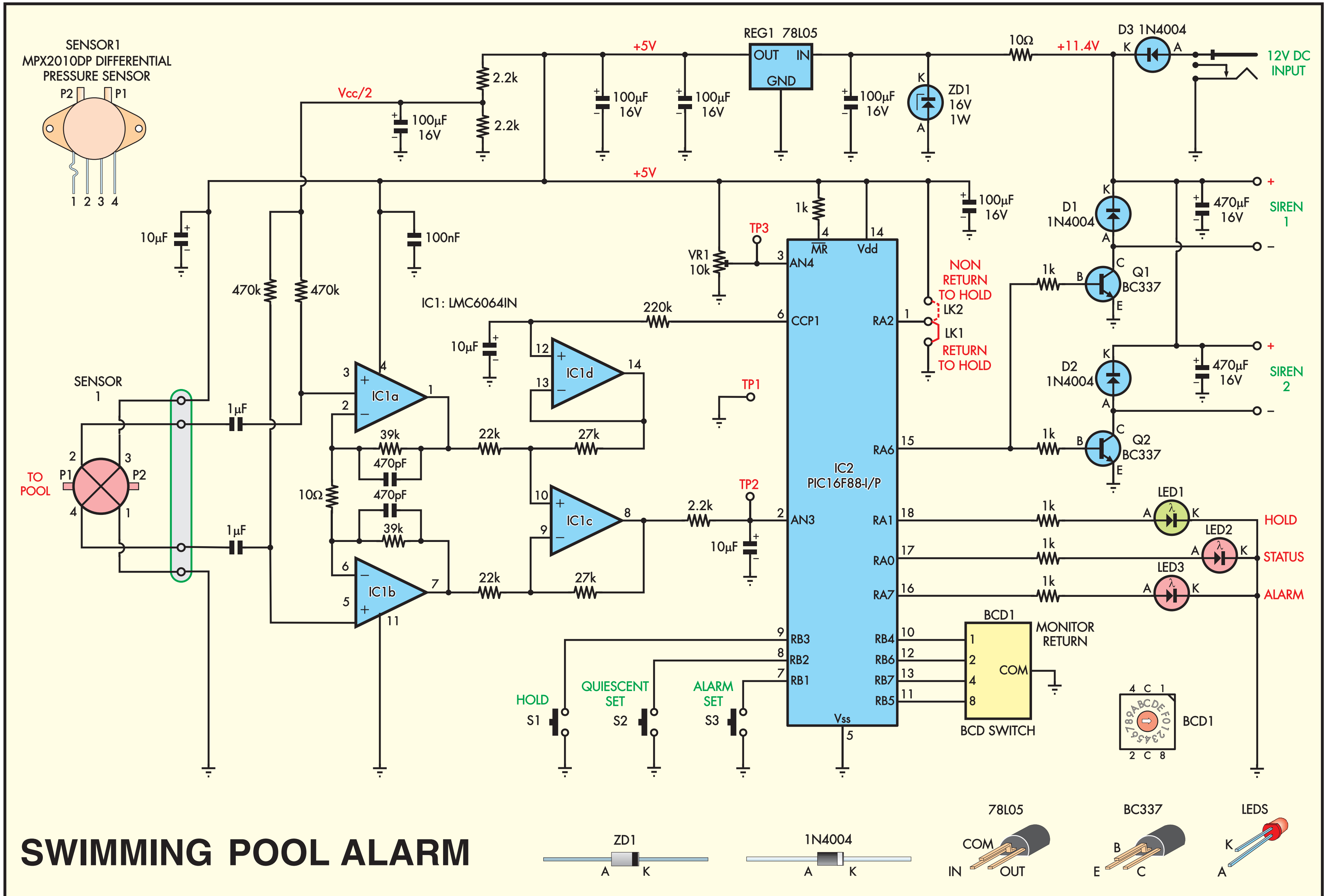
As already noted, the CCP1 output at IC2 pin 6 produces the PWM signal. It is initially preset so that the output of IC1c is nominally at +2.5V. However, because of manufacturing tolerances in IC1, the output could vary and so there is a set-up procedure (to set the output to 2.5V).

Pressing switch S2 before power is applied to the circuit runs this procedure. The program within IC2 then adjusts the PWM percentage so that the reading at port AN3 is at +2.5V. This process takes about 60s. The new PWM value is then stored and used every time the pool alarm is powered up.

IC2 operates at 500kHz using an internal oscillator, and is run from a 5V supply derived from regulator REG1.

Software

The software files are available via the *EPE Library* site, accessed via **www.epemag.com**. Pre-programmed PICs will also be available from Magenta



SWIMMING POOL ALARM

Fig.3: the circuit uses Sensor 1 to sense pressure variations due to waves in the pool. The differential outputs from the sensor (pins 2 and 4) are then amplified by op amps IC1a-IC1c and fed to PIC microcontroller IC2. IC2 then processes the data and drives the sirens (via transistors Q1 and Q2) and status LEDs.

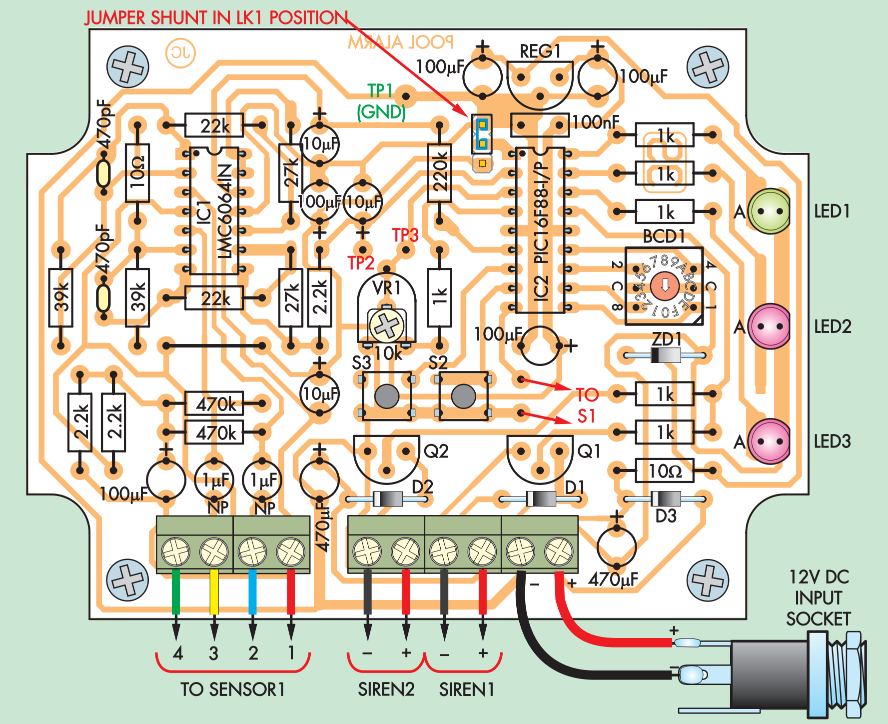


Fig.4: the parts layout for the Pool Alarm. Note the jumper pins (top centre) which must match your requirements – see text.

Electronics – see their advert in this issue for contact details.

Construction

The Pool Alarm is built on a PC board, code 762, measuring 102mm × 77mm. This board is available from the *EPE PCB Service*.

The board is housed in an IP65 sealed polycarbonate enclosure with a clear lid (115mm × 90mm × 55mm). Similarly, the pressure sensor is housed in an IP65 sealed ABS case measuring 64mm × 58mm × 35mm.

The wiring details for the PC board are shown in Fig.4. Start the assembly by checking the PC board for any defects, such as shorted tracks and breaks in the copper. You should also check the hole sizes. The holes for the corner mounting screws need to be 3mm in diameter, while the holes for the screw terminals need to be 1.2mm. Check also that the PC board will fit into the box.

Install the single wire link and the resistors first. Use the resistor colour code table as a guide to finding each value. Better still, use a digital multimeter (DMM) to check each resistor before installing it. That done, install the PC stakes for test points TP1 to TP3 and for the connections to S1, then fit the 3-way header for links LK1 and LK2.

Next, install diodes D1 to D3 and Zener diode ZD1. IC1 can now be mounted, but just insert and solder in the socket for IC2 at this stage. Both the IC and socket must be oriented correctly.

The capacitors can go in next. Note that the electrolytic types must be oriented with the correct polarity, as shown. Now install transistors Q1, Q2 and regulator REG1, taking care not to mix them up, then install trimpot VR1 and the BCD switch (BCD1). **The correct orientation for BCD1 is with the dot to the lower right – see Fig.4.**

Switches S2 and S3 can be inserted next. These will only fit easily on the PC board with the correct orientation. Last, the screw terminals can be inserted. Note that the 6-way terminals are made up of three 2-way terminals that are interconnected using the moulded dovetails that attach the pieces together. The 4-way terminals are made using two 2-way terminals.

Pool alarm box

Work can now be start on the main Pool Alarm box. First, drill a hole in the lid for S1, plus holes in the box for the cable glands for the sensor and siren wiring. You will also need a hole for the DC input socket.

That done, place the PC board in the box and secure it with four M3 × 6mm screws. You can now attach the panel label (see full-size artwork below Parts List) to the lid, install switch S1 and insert the neoprene seal that is pressed into the lid surround.

Next, wire up the DC socket to the screw terminals and wire switch S1 to the two terminals on the PC board. That done, connect a 12V DC plugpack to the DC socket and apply power. Check that there is +5V between pins 11 and 4 on IC1 and at pins 5 and 14 on IC2's socket. If the voltage is within the range of +4.75V to +5.25V, then power can be disconnected and IC2 installed in its socket.

Apply power again and measure the voltage between TP1 (GND) and TP2. **This should be about 2.5V, but if this differs by 0.25V, you will need to run the set-up to adjust TP2 to sit at 2.5V.** This needs to be done at a later stage when the pressure Sensor is connected.

Sensor box assembly

The full assembly details for the Sensor box are shown in Fig.5.

First, a baseplate is made up using sheet aluminium measuring 31 × 26mm.

Table 1: Resistor Colour Codes

	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	2	470kΩ	yellow violet yellow brown	yellow violet black orange brown
❑	1	220kΩ	red red yellow brown	red red black orange brown
❑	2	39kΩ	orange white orange brown	orange white black red brown
❑	2	27kΩ	red violet orange brown	red violet black red brown
❑	2	22kΩ	red red orange brown	red red black red brown
❑	3	2.2kΩ	red red red brown	red red black brown brown
❑	6	1kΩ	brown black red brown	brown black black brown brown
❑	2	10Ω	brown black black brown	brown black black gold brown

This is then fitted with two M3 × 20mm screws and M3 nuts for the sensor, and attached to two central mounting posts in the box using M3 × 6mm screws.

That done, the sensor can be slipped onto its mounting screws (notched pin to the left) and secured using two more M3 nuts. Note that the sensor is oriented so that port 1 is the one that is connected to the tubing.

The wiring can now be connected to the four sensor pins, with the cable exiting through the adjacent end of the box via a cable gland. Take care with this wiring and make a note of the wire colour used to make each connection.

If you are using flat 4-way cable, it will not form a watertight seal within the gland. Applying a small amount of silicone sealant around the wire where it passes through the gland can provide this waterproofing.

The Port 1 connection to the sensor consists of a 3mm PVC tube that's covered with a 145mm length of metal tubing. This assembly is passed through the cable gland and clamped in place.

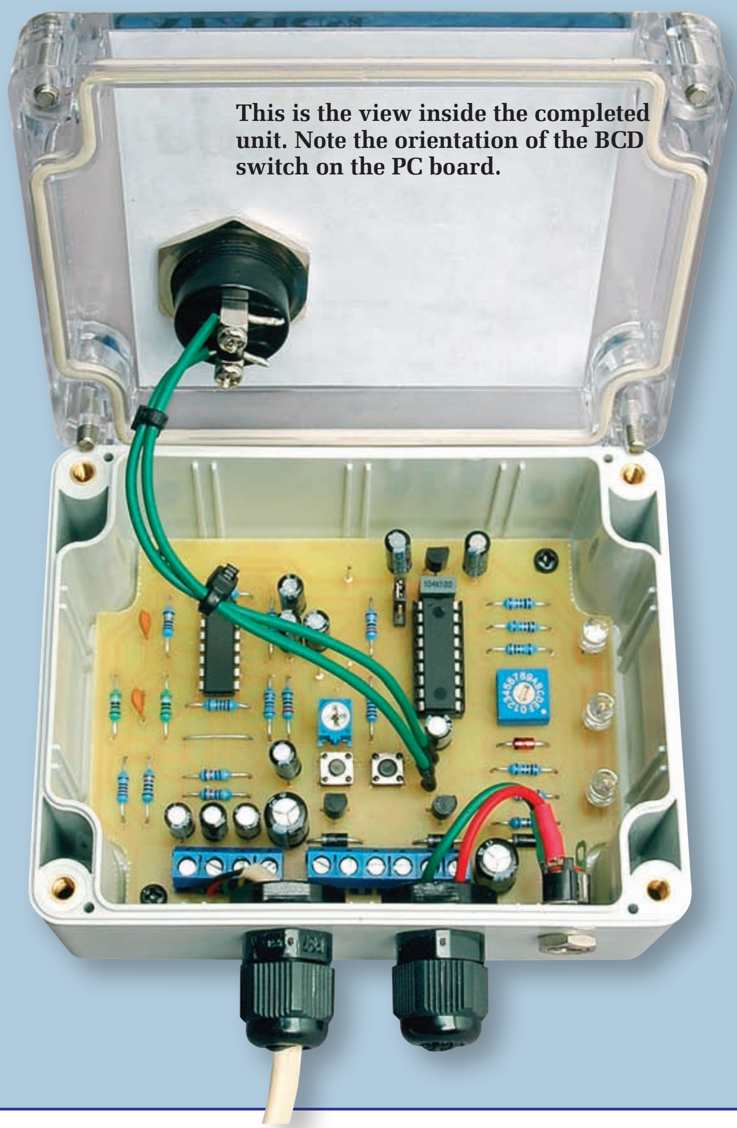
The metal tube maintains an even temperature inside the vinyl tube, keeping it at the same temperature as the pool water. The metal tube also keeps the vinyl tubing straight and holds it in place at a fixed depth in the water.

If you need to run the TP2 set-up, this can be done now. With power off, temporarily connect the sensor to the alarm PC board terminals, taking care that everything is correct. Now press switch S2 and reapply power. The Status LED should light and the TP2 voltage will be seen to vary and finally settle at about 2.5V after 60 seconds.

The sensor box can now be mounted at the pool, with the probe tip immersed by about 60mm to 90mm. The box can be attached to the side of the pool using brackets to the ladder or secured to the side of the pool using an underwater-curing epoxy such as Bostik Titan Bond Plus.

Note that when using the box mounting holes, it has two mounting screw points that are effectively located outside of the box enclosure, but which are accessed with the lid off.

The sensor box must be located so that it does not receive the force of the filter pump outlet. In addition, the filter outlet nozzle should be adjusted so that it does not cause turbulence at the top of the water.



This is the view inside the completed unit. Note the orientation of the BCD switch on the PC board.

The wiring between the sensor box and Pool Alarm needs to be protected from damage by using conduit in areas where it is exposed. This conduit can be placed underground.

You can use one or two sirens with the alarm. These can be located in different parts of your property to provide full sound coverage. It is best to have these disconnected until the Pool Alarm is calibrated.

Calibration

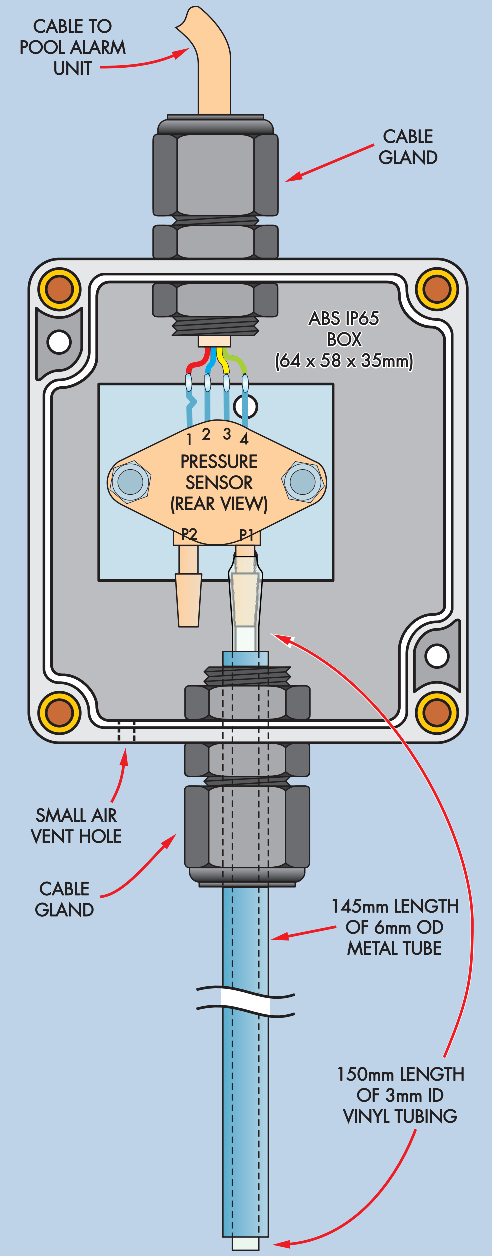
The calibration is carried out by using on-board switches S2 and S3 to set the water movement levels that correspond to your pool.

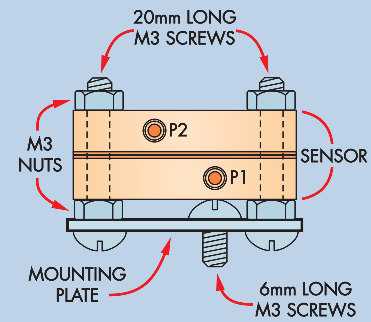
For the alarm level, you need to simulate pool water movement when a small child falls into the water. To do this, fill a 10 to 12-litre bucket with water, about one-third full, and drop the bucket from about 30mm above the pool water into the pool. Press S3 (Alarm Set) to record the movement. The Status LED will light during this procedure.

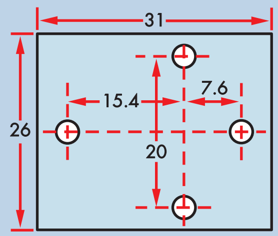
Note that the calibration may not be successful if the wave from the bucket does not reach the sensor during the 10s calibration period. If it doesn't calibrate, try again (after the pool water has settled) and wait until the wave caused by the bucket has almost reached the sensor before pressing S3. You will need to try this at different points around the pool.

Quiescent alarm calibration

Quiescent alarm calibration should be done with the filter pump operating and with a typical breeze blowing across the pool. Press S2 (the Quiescent Set switch) during these events to record the water movement levels. The Status LED will







MOUNTING PLATE
(18g ALUMINIUM)

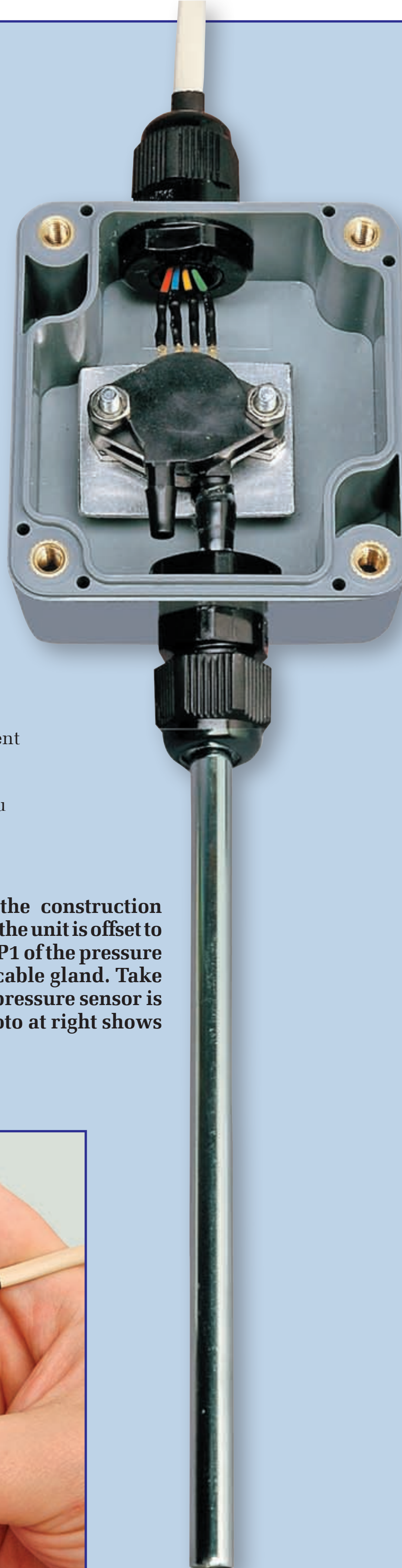
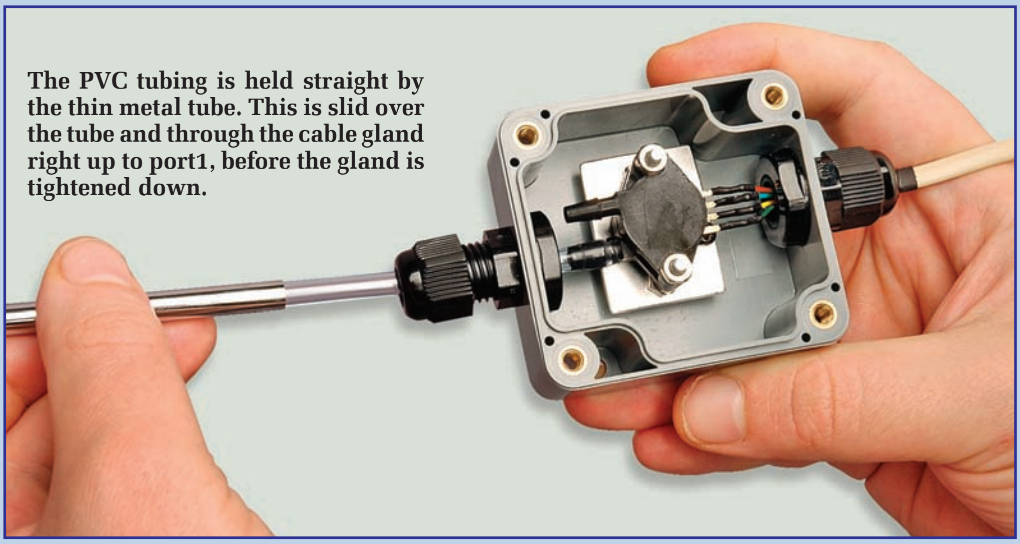


Fig.5 (left): this diagram shows the construction details for the sensor unit. Note that the unit is offset to the left inside the case, so that port P1 of the pressure sensor lines up with the adjacent cable gland. Take care with the wiring – pin 1 of the pressure sensor is the lead with a notch in it. The photo at right shows the completed unit.



The PVC tubing is held straight by the thin metal tube. This is slid over the tube and through the cable gland right up to port1, before the gland is tightened down.

Table 2: Setting The Alarm Period

VR1 Setting (measured between TP1 and TP3)	Alarm Period
0.5V	30 seconds
1.0V	1 minute
1.5V	1.5 minutes
2.0V	2 minutes
2.5V	2.5 minutes
3.0V	3 minutes
3.5V	3.5 minutes
4.0V	4 minutes
5.0V	5 minutes

Table 3: Monitor Return Settings

BCD Setting	Return Period
0	No return
1	1.25 minute
2	2 minutes
3	3 minutes
4	4 minutes
5	5 minutes
6	6 minutes
7	7 minutes
8	8 minutes
9	9 minutes
A	10 minutes
B	20 minutes
C	30 minutes
D	45 minutes
E	60 minutes
F	75 minutes

light during this time and extinguish after 10 seconds.

Note that this quiescent level must be less than the alarm level in order for the 'return to monitor' function and for the 'set to hold' feature to work.

Now set the alarm period using VR1, noting that the voltage at TP3 will show the timeout. A 1V setting gives a one-minute alarm, while 2V gives two minutes and a 5V setting provides a five-minute alarm – see Table 2.

Next, select whether you want the 'return to hold' feature with LK1 or LK2 and set BCD1 for the required return to monitor period – see Table 3. If 'return to monitor' is used (for settings other than 0), then select the setting that best suits your pool use.

If you tend to vacate the pool area after swimming, then the 'return to monitor period' can be set to a short period. If you tend to swim and then sunbake, then a longer period may be necessary to prevent the pool alarm sounding when you return for a swim. ***EPE***

Parts List – Pool Alarm

1 PC board, code 762, available from the *EPE PCB Service*, size102mm × 77mm
1 IP65 sealed polycarbonate enclosure with clear lid, size 115mm × 90mm × 55mm (Jaycar HB-6246 or equivalent)
1 IP65 sealed ABS case, 64mm × 58mm × 35mm
1 sheet 18g of aluminium, size 26mm × 31mm
1 12V 400mA DC adaptor
1 piezo siren (Jaycar Cat. LA5308 or LA5256)
1 piezo siren as above (optional)
1 MPX2010DP Freescale Semiconductor pressure sensor (Jaycar ZD-1904 or equivalent) (Sensor1)
1 SPST waterproof momentary switch (Jaycar SP-0732 or equivalent) (S1)
2 SPST micro tactile switches (Jaycar SP-0600 or equivalent) (S2,S3)
1 BCD DIL rotary switch (0-F) (Jaycar SR-1220 or equivalent) (BCD1)
5 2-way PC-mount screw terminals with 5mm or 5.08mm spacing
1 2.5mm DC panel socket
4 3-6.5mm diameter IP68 waterproof cable glands
1 2-way pin header, 2.54mm spacing
1 18-pin DIL IC socket
2 M3 × 20mm screws
6 M3 × 6mm screws
4 M3 nuts
3 PC stakes
1 150mm length of medium duty hookup wire
1 30mm length of 0.8mm tinned copper wire
1 length of 2-pair (4-wire) telephone sheathed cable or 4-core alarm cable (to suit)
2 100mm cable ties
1 150mm length of 3mm ID (5mm OD) vinyl tube
1 145mm length of 5mm ID (6mm OD) metal tubing

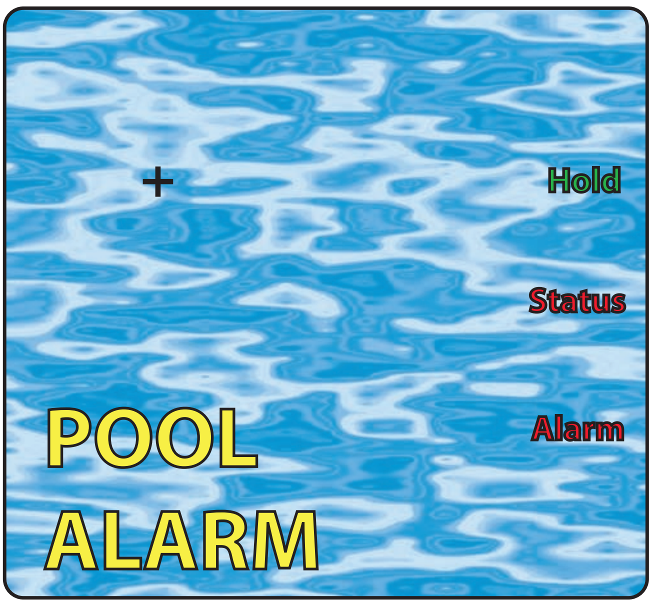
Semiconductors
1 LMC6064IN quad op amp (IC1)
1 PIC16F88-I/P preprogrammed microcontroller (IC2)
2 BC337 *NPN* transistors (Q1,Q2)
3 1N4004 1A diodes (D1-D3)
1 16V 1W Zener diode (ZD1)
1 5mm green LED (LED1)
2 5mm red LED (LED2,LED3)

Capacitors
2 470μF 16V PC radial elect.
5 100μF 16V PC radial elect.
3 10μF 16V PC radial elect.
2 1μF NP radial elect.
1 100nF MKT polyester
2 470pF ceramic

Resistors (0.25W 1% metal film)

2 470kΩ	2 22kΩ
1 220kΩ	3 2.2kΩ
2 39kΩ	6 1kΩ
2 27kΩ	2 10Ω

1 10kΩ horizontal trimpot (VR1)



What's That?

Mark Nelson

If you're a diabetic, it might just be a complete medical lab in a package smaller than most mobile phones. Medical electronics can now also diagnose early onset of conditions like glaucoma, while an 'electrowetting' technique can create liquid optical lenses. Mark Nelson focuses on these mini miracles.

It's a cruel irony of the communications overload of today's information era that diabetes remains a closed book to so many people. According to the charity Diabetes UK, up to half a million people in the UK have diabetes but do not realise they have it. Nor are they aware that if untreated, it can be fatal. Treatment often involves regular monitoring of blood glucose levels and with today's overburdened healthcare resources, self-diagnosis is the most cost-effective solution.

A lab in the palm of your hand

Keeping an accurate watch on your blood sugar levels is an integral part of successful diabetes management and personal blood glucose meters are a vital means of simplifying diabetes treatment. There are well over a dozen models available in the UK, each is battery operated and significantly smaller than a mobile phone handset (about the same size as a pocket pedometer).

Generally, they work by lancing (pricking) your finger (almost) painlessly to extract a minute drop of blood for analysis, and can take as little as five seconds to provide accurate blood sugar level results. A typical modern device can store 500 readings to show the user a 7, 14 or 30-day average, with an alarm buzzer to remind him or her when it's time to perform another test. An infrared port located at the top of the device allows the meter to communicate with a home PC.

The amazingly low (subsidised) cost of these vitally necessary devices belies the highly sophisticated electronics 'under the hood'. Many of them employ a so-called amperometric electrochemical reaction to read the glucose level in the blood. Expressed simply, measuring an electric current passed through a liquid between two electrodes indicates the concentration of the glucose present. In fact, a similar process is used in chocolate factories to control the different sugars to ensure batch reproducibility and maintain the flavour profile that consumers demand from a particular brand.

A popular semiconductor for glucose measurement in blood glucose meters is the Texas Instruments 7001201, which reads the current flowing through the blood sample and provides the result to a MSP430U334 custom microcontroller (also from Texas), which handles the calculation and storage of results, controlling the LCD readout and the infrared port.

A boon but…

For many sufferers, these blood glucose meters are an absolute boon, but some observers are not satisfied. They say that these devices are viewed by manufacturers as revenue generation devices, not as devices for real blood glucose control. Also, that little is done to make this technology improve health and healthcare outcomes.

It's certainly true that the meters are almost given away (so that industry can make the real profit on the special test strips used), but also that the information given by the meters is presented so ineffectively that few consumers or health providers actually use it. Users cannot relate the readings to the things affecting them: food, exercise, insulin injections or medications. No attempt is made to reveal patterns which can be used to change therapy and improve people's blood sugars.

These readings could be made more meaningful by enabling the portable meters to communicate with a sophisticated computer network, which could analyse each user's results and advise them what next to do. A step in this direction is the European Commission's current funding of £6.2 million for a portable personalised blood glucose prediction tool called DIAdvisor.

This joint industry and academic scheme is halfway through its four-year term. Analysis of physiological inputs from non-intrusive body-worn wireless monitors will provide information and trend data directly to healthcare providers, to enable further therapy improvements and reduce the cost of treatment. Will this hugely expensive development provide value for money, or solve most sufferers' problems? only time will tell.

Have you got it?

I know you buy *EPE* to read about practical electronics, not medical matters, but I'd be failing if I didn't explain why the care of diabetes patients was such a big deal. Diabetes is an 'invisible' illness, without any outward signs of its highly unwelcome outcomes. There are currently over 2.6 million people confirmed with diabetes in the UK and up to half a million more who are undiagnosed (I was one of the totally unaware ones).

If you suffer an unquenchable thirst, frequent toilet trips, occasional blurred vision and wobbles or permanent tiredness, do see a doctor as these are the classic signs of diabetes. Diabetes is not curable, but it's treatable, and 90 per cent of sufferers can control it by being careful with their diet, taking tablets or a combination of both. Ignoring the symptoms will have very unpleasant consequences. Now back to electronics.

Taking the strain

Glaucoma is a disease in which the optic nerve is damaged, leading to progressive, irreversible loss of vision. The second most common cause of blindness around the world, its symptoms can include the patchy loss of peripheral vision, reduced clarity of colours and halos around lights, all of which require examination by an eye specialist.

Because the condition is usually associated with increased pressure of the fluid in the eye, an electronic pressure gauge would be an ideal diagnostic tool, which is what prompted the Swiss company Sensimed to develop Triggerfish, an ingenious 'smart' contact lens that incorporates a minute embedded strain gauge for monitoring the contours of the eye. The lens itself does not interfere with normal vision and can remain on the eye while the user is asleep.

Whereas normal contact lenses are worn daily, Triggerfish is used only for a period of 24 hours (typically). This is because it's used not for correcting sight, but as a diagnostic tool, providing valuable disease management data that is not currently obtainable using conventional ophthalmic equipment.

Another difference from normal contact lenses is that whereas they are self-contained units, Triggerfish is a multi-part device. The contact lens part incorporates a telemetric sensor that 'talks' to a ring-patch worn around the eye that in turn is attached to a recording device similar to a small pocket dictation machine.

Currently, Triggerfish is used only in a few, selected and closely controlled medical centres in Europe, but both Sensimed and ST Microelectronics (the company that developed the combined strain gauge and radio antenna) are looking to create a version that can be mass-produced for widespread use all over the world.

Liquid lens

An equally ingenious optical device is the liquid lens that Varioptic has developed in France. Unlike 'solid' conventional lenses made of glass or plastic, the liquid lens is essentially fluid, being a droplet of oil inside a thin glass cell.

A clever 'electrowetting' technology alters the surface tension of the liquid, leading to a change of the focal length of the lens. With no moving parts the lens consumes only flea power (less than 50mW) and with suitable electronics gives auto-focussing and image stabilisation. This, says the company, will bring the full digital camera experience to mobile phone users.

DSP Musicolour: calibrating and operating

Part 3:
By MAURO GRASSI

In last month's article, we detailed the construction of the DSP Musicolour. In this month's article, we guide you through the final testing of the DSP Musicolour and give troubleshooting tips. We also explain the operation of the firmware in more detail as well as discussing possible accessories.

While the circuit of the *DSP Musicolour* (published in *EPE* in May 2010) may at first seem complicated, it is relatively simple when you consider all the features that we have been able to pack into this powerhouse. Check out the list opposite. We think you'll agree!

We assume that you have read the first and second parts of the article in the previous two issues of *EPE*. If you have followed the construction in last month's issue, you should have a fully assembled DSP Musicolour in its case, and you should have tested the supply rails at test points TP0 and TP1. These should have measured close to their correct values of +5V and +10V respectively.

If they do not measure close to these values, you should refer to the troubleshooting section below for further hints, although we did mention some extra checks to perform in last month's issue, to which you should refer first.

In last month's article, we mentioned that link LK4 is optional and is normally omitted. When LK4 is omitted, the DSP Musicolour has three independent audio inputs that can be used to modulate the output channels. These are the Microphone input, the Left Audio channel and the Right Audio Channel.

The Left and Right Audio channels from the speaker terminals on the back panel are attenuated by the Left and Right potentiometers on the front panel. The Microphone line input is a mix of the on-board electret microphone signal and any external microphone connected to the 6.5mm jack on the back panel.

When LK4 is installed, however, the Left and Right Audio channels from the back panel are mixed in hardware before being digitised by the microcontroller. In this case, either the Left or Right potentiometer can be used to attenuate the input signal before it is digitised (and you should not install both potentiometers).

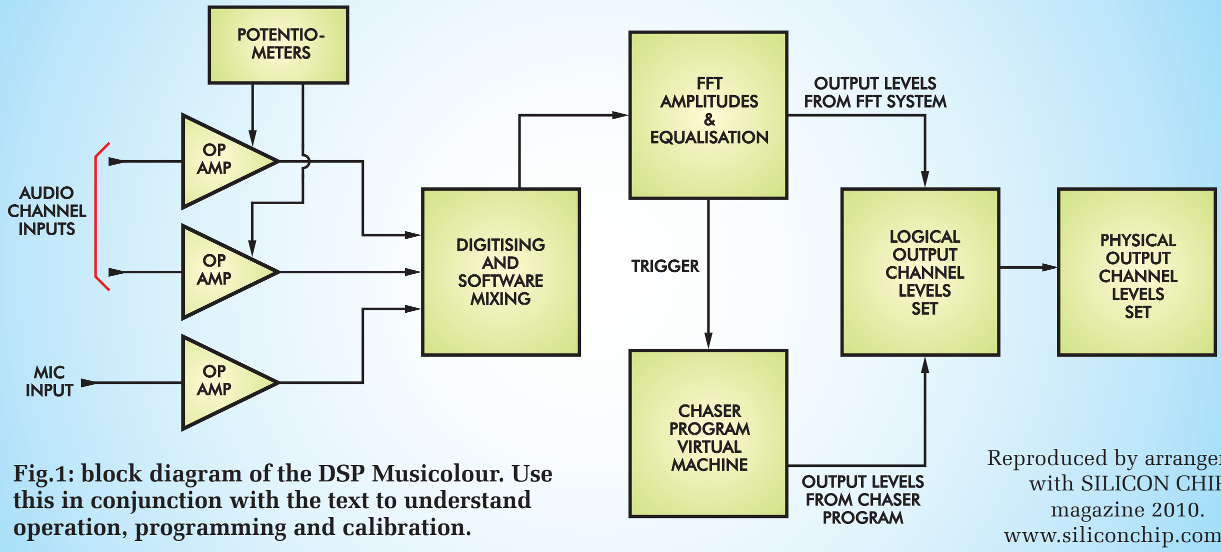


Fig.1: block diagram of the DSP Musicolour. Use this in conjunction with the text to understand operation, programming and calibration.

In other words, when LK4 is installed you lose one independent audio channel, but you need only one potentiometer on the front panel. Link LK4, therefore, controls whether the DSP Musicolour Left and Right audio channels are mixed in hardware or software (dual mono or joint stereo). The most common option is to omit LK4 and to disable hardware mixing.

With regards to jumper links LK5 and LK6, we mentioned in the first part of the article that the default is to have LK5 installed and LK6 omitted. In fact, the firmware will ignore the state of links LK5 and LK6 – it does not matter if they are installed or not.

Power up

First, make sure that the plastic case has been screwed shut. When you first apply power, you should see the start up screen scroll past on the dot matrix LED display.

The DSP Musicolour will go through a number of tests and then go to its default state. If it does not, you should switch off mains power immediately and go to the troubleshooting section below.

Boot-up sequence

When the DSP Musicolour first boots up, it goes through a number of internal checks before commencing operation. The following occurs on boot up (in chronological order):

1. The firmware displays the start up screen and its version number (this can be disabled for a quicker boot by changing the start up settings in the SYSTEM>Startup submenu).
2. The firmware measures the frequency of the mains supply. If the measured value is within tolerance, the firmware accepts the measured value and assigns its internal settings for either 50Hz or 60Hz operation (the firmware chooses the value closest to the measured frequency).

   If the measured value is not within tolerance, the firmware will display a warning indicating that no mains was detected and will default to 60Hz operation. In normal mains-powered operation, this warning should never be seen. If it is, it indicates a problem with the Musicolour's zero crossing detection system.

   The fallback value of 60Hz was chosen because it is the safer value for the purpose of controlling the triacs in the output stages.

DSP MUSICOLOUR FEATURES

1. Selectable 8-band equaliser
2. Auto detection of mains frequency (50Hz or 60Hz)
3. Selectable phase-controlled or zero voltage-switched output channels (8-bit resolution)
4. For each logical output channel:
   (a) Selectable gain
   (b) Selectable audio passband: arbitrary minimum and maximum frequencies
   (c) Selectable acquisition mode: peak or average
   (d) Selectable quiescent level (filament preheat)
   (e) Selectable ZV (zero voltage) mode, Strobe mode, Direct mode or Continuous mode
5. Selectable logical channel for each physical output channel
6. Chaser modes implemented as a virtual machine
7. Trigger channel with:
   (a) Selectable audio passband
   (b) Selectable trigger threshold
8. Firmware support for RC5 remote control (requires additional PC board; to be described next month)
9. Firmware support for high speed UART (requires additional PC board)
10. Selectable balance
11. Selectable display frequency, brightness and screen saver time-out period
12. Selectable sampling frequency, from 16kHz to 50kHz simultaneous on all channels
13. Real time 7-bit FFT using double buffering
14. Persistent software settings and multiple non-volatile user memories
15. Self-calibration and diagnostics
16. Automatic and manual tuning of the internal fast RC oscillator for increased accuracy
17. Adaptive potentiometer controls
18. Silence detection and triggering
19. Input op amp stage clipping detection

3. If you are running from a 50Hz supply, and somehow the frequency is not properly detected and defaults to 60Hz, the shorter mains period will at worst mean that less power is delivered to the output loads. Therefore, even if your mains supply is 50Hz and the detection fails, at least the outputs will not flicker. Flickering can occur when the triacs are switched on beyond the next zero crossing of the mains waveform and should not occur in normal operation.

   Another fail-safe feature is that in the rare event that no good mains frequency is detected, the firmware will disable all output channels (the rest of the firmware will function normally, however).
4. The firmware will load any persistent settings from the last active session and initialise all internal peripherals, including enabling all interrupts in the correct sequence.
5. The firmware will detect and enable any connected accessories. It is possible to add a small infrared remote control PC board to the main board to allow the DSP Musicolour to be operated by a standard RC5 remote control.

   Also, the firmware implements an RTSP (Run Time Self Programming) server in a secure part of program memory (it also switches the interrupt vectors to an alternative location), which can be used with a UART. The DSP Musicolour is highly customisable, but for most applications, you will not need to change any settings, as the preloaded defaults should be adequate.
6. The firmware will jump to the main loop (described below).

Automatic calibration

Although the DSP Musicolour will adjust its settings according to the detected mains frequency, all its calculations assume a fixed system clock.

The system clock is derived from the microcontroller's (dsPIC30F4011) internal fast RC oscillator (nominally 7.37MHz) and a 16× PLL multiplication stage is used to achieve around 30MIPs operation (4 clocks per instruction).

Since this oscillator's frequency tolerance can be relatively high, due to internal manufacturing variations, it may be necessary, if you are experiencing unusual effects like flickering lights on the output channels, to calibrate the frequency as close to 7.37MHz as possible. This is a good thing to do – just in case.

The dsPIC30F4011 has an internal non-volatile calibration setting to achieve this, meaning the internal fast RC oscillator can be tuned to bring it as close as possible to its intended frequency. The firmware assumes that the mains line frequency is very close to its theoretical value of either 50Hz (if you are in Australia, Europe and most other parts of the world) or 60Hz (if you are in America, Japan and a few other places).

Since the mains frequency can be measured by the firmware against the system clock, the firmware can then calculate the error in the internal fast RC oscillator and automatically adjust it to minimise the error.

This is what the firmware does in its automatic calibration. It will run once when you first power up, but if you need to, you can also do it manually.

To do this, go to the ADVANCED>Calibration submenu. If you wish to see how far from the ideal the microcontroller is operating, go to the INFORMATION>Error menu, and the current percentage error in the measured mains frequency will be displayed.

The main loop

After boot up, the firmware spends most of its time in the main loop, where the Musicolour is either in Automatic mode (AUTO LED is lit) or User Mode (USER LED is lit). Either way, the AUTO LED or the USER LED will flash if no input signal is detected.

The SET LED will also flash if there is clipping (overload) in the op amp stages of either the Left or Right audio input channels.

While clipping is very undesirable in an audio amplifier, greatly affecting the sound quality, its effect may actually help in getting a good display from the DSP Musicolour. So the detection of clipping is merely an indication that you may want to turn down the Left and Right potentiometers.

While in the main loop, you may enter the menu system by pressing the SET button. The display is refreshed according to the currently selected display. The selected display can be scrolled to the next available display using the AUTO button when already in Automatic Mode, and the USER button when already in User Mode.

Some of the implemented main loop displays are shown in Table 1. Note that they do not affect the internal operation of the DSP Musicolour; they only affect what the display shows.

In the main loop in Automatic Mode, the CH1 to CH4 LEDs will light according to the logical output channel levels. The main difference between Automatic mode and User Mode is that in Automatic mode the Musicolour uses its current settings for all functions, whereas in User Mode, one of four previously stored settings profiles is used instead.

Thus, User Mode can be used to quickly run the Musicolour in a previously set configuration. In User Mode, the CH1 to CH4 LEDs will indicate one of the four preset profiles currently active. You may press the CH1-CH4 buttons to change the preset on the fly while in User Mode.

The main loop running in Automatic or User Mode consists of the following sequence, as shown in Fig.1.

Table 1: The display modes in the main loop

Spectrum Fine	**The spectrum is displayed on the display from lowest to highest frequency (left to right).**
Spectrum Centered	**The spectrum is displayed in centred mode.**
Logical Channel Displayed Single	**The output levels of each channel are displayed. The top horizontal bar indicates the first logical channel's level. The third horizontal bar from the top indicates the second logical channel's level.**
Logical Channel Display	**Similarly, the fifth and seventh horizontal bars from the top indicate the third and fourth logical channels' levels respectively.**
Averaging	**Same as above, except every horizontal bar in between the output channel bars is the average of the previous and next bars.**
RMS display	**Displays the RMS level of the input signal as an analogue meter.**

Logical and physical channels

We should first mention that the firmware supports four logical output channels and four physical output channels. The physical output channels correspond to the outputs on the back panel. Each of these can be associated to a logical channel. In normal operation, the physical channel N is associated to the logical channel N.

However, added effects can be achieved by changing the mapping from output channels to logical channels. For example, you can have all four physical channels on the back panel controlled by one logical output channel.

We now explain the operation of the main loop. As can be seen in Fig.1, the three inputs consisting of the Left and Right audio inputs and the Microphone inputs are digitised and mixed according to the balance settings under AUDIO>Balance. Any combination of these three channels can be used as the input signal. The result of this software mixing is passed to the FFT (fast Fourier transform) system.

The output of the FFT resolves the captured slice of the input audio waveform into 128 (2^7) frequency amplitudes. These are equally spaced from 0Hz up to the sampling frequency. The smallest frequency that the FFT can resolve is F/128, where F is the sampling frequency. For example, when F is 48kHz we can resolve down to 375Hz or ±137Hz. If you are not very interested in the audio sub-band above, say, 10kHz, then you can lower the sampling frequency to 20kHz and the FFT will be able to resolve frequency components down to 156Hz or ±78Hz.

The audible spectrum for humans is nominally from about 20Hz to 20kHz. Although the sampling frequency of the ADC system can be set anywhere from 16kHz up to 50kHz, keep in mind that according to the Nyquist sampling theorem the highest frequency that can be resolved using a sampling frequency F is F/2.

This means that aliasing will occur at least somewhere in the audible spectrum if the ADC system's sampling frequency is set below about 44kHz. Aliasing is usually an unwanted characteristic of a digitising system. However, since most music has very little high harmonic content, in fact little content above 4kHz, it may be desirable to lower the sampling frequency in order to increase the resolution of the FFT.

The FFT system computes logical output channel levels in two acquisition modes. These can be set in the CHANNELS>Mode submenu.

The two acquisition modes are PEAK and AVERAGE. In AVERAGE mode, the average of the relevant frequency components falling within the channel's passband (set by the minimum and maximum frequencies for the channel) will be the output level requested in the output stage. In PEAK mode, however, only the maximum level within the channel's passband will be the output level requested in the output stage.

There is an optional Equaliser module, which can be enabled or disabled. The levels of the equaliser can be changed, however, by going to the AUDIO>Equaliser submenu.

The equaliser has eight bands set to affect preset portions of the audible spectrum. The current equaliser bands can be seen under the INFORMATION>Equaliser submenu, and cannot be changed by the user (it can, however, be changed by reprogramming the device).

Note that the equaliser affects the output of the FFT, not the input. After any equalisation is performed, the levels of the logical output channels are set by the FFT system, if the chaser mode is set to OFF (see the CHASER>Mode submenu below).

If the chaser mode is not set to OFF then the level data produced by the FFT system is ignored and the data produced by the current chaser program (see the CHASER>Program submenu below) is used to set the logical output channel levels instead. If the chaser mode is set to TRIGGERED, then the trigger pulse (produced by the FFT system) is used to step through the chaser program.

Warning!

The DSP Musicolour operates from the 230/240V AC mains, and many internal components and sections of the PC board tracks are also at mains potential. Contact with any of these could be FATAL.

DO NOT TOUCH any of these parts unless the power cord is unplugged from the mains supply. DO NOT CONNECT this device to the mains unless it is fully enclosed in the specified case.

This project is not for the inexperienced. DO NOT BUILD IT unless you know exactly what you are doing and are completely familiar with mains wiring practices and construction techniques.

Triggering

Triggering can either occur directly from the Trigger channel or from the Silence detection. Silence detection triggers when there is a relative silence in the input Left or Right audio signals (the MIC input is not used for the silence detection).

The trigger can be considered a separate logical channel, which has its own selectable passband and threshold. When the threshold is reached, the trigger occurs. The trigger is used by the chaser system to trigger the current chaser program in TRIGGERED mode.

Tips: if, for example, you want bass response triggering a pre-set chaser program, you would set the TRIGGER minimum frequency to 0Hz and the maximum frequency to around 300Hz. Then adjust the threshold level to get an acceptable level of triggering.

Light Chaser

The chaser program is either executed at the rate set in OUTPUT>Output Rate, or each step in the program is triggered. Both the Chaser system and the FFT system produce a set of output levels for the logical output channels. Depending on the chaser mode being used, the chaser levels or the FFT levels will be used to change the levels of the logical output channels. These will then affect the physical output channels.

Channel modes and settings

Each of the four logical output channels can operate in one of four primary modes: DIRECT mode, CONTINUOUS mode, ZV mode (zero voltage switching) or STROBE mode.

In the DIRECT and CONTINUOUS modes, the brightness of the logical output channel is varied in 256 levels (8 bit resolution). The output brightness is approximately

linear, as the firmware uses an internal dimming curve to correct the non-linearity inherent in phase control. The difference between DIRECT and CONTINUOUS mode is how the output level is set by the output system.

The main difference between the DIRECT and CONTINUOUS modes is that while in DIRECT mode the brightness is set directly, in CONTINUOUS mode, the brightness is 'continuously' modified from the current brightness level.

In other words, in CONTINUOUS mode, if the requested level is higher than the current level, the current level is increased by the ATTACK setting for the channel, while if the requested level is lower than the current level, the current level is decreased by the DECAY setting for the channel. Setting different ATTACK and DECAY levels for the channel can affect the level of the output logical channels in CONTINUOUS mode.

In ZV mode, the output channel responds as in DIRECT and CONTINUOUS modes, except that the output is not a brightness level but a digital output. The output is either fully on or fully off. This mode approximates a zero voltage switching mode and can be used to reduce RF interference or achieve a digital effect.

In STROBE mode, the output level sets the frequency of the logical output channel rather than the brightness level. The strobe frequency will be set from the maximum (equal to the mains supply frequency, either 50Hz or 60Hz, down to 1/256th of the mains supply frequency; ie, around 0.2Hz).

Quiescent level or filament preheat

In all channel modes except STROBE, each logical output channel has a settable quiescent level, which is used to reduce the stress on the filaments in your incandescent lamps and to reduce surge currents through the triacs at switch on.

The quiescent level can be set by going to OUTPUT> Quiescent Level and is settable from 0 to 25% of the full brightness level. Note that if the channel mode is ZV and the Quiescent Level is not 0%, the channel may seem to be continuously on, depending on the ZV threshold. In this case, you should set the Quiescent Level to 0% or disable ZV mode, or change the ZV threshold by going to OUTPUT>ZV Threshold.

A closer look at the operation of the Musicolour

The triacs are controlled through the optocouplers using the four output compare channels of IC1 (dsPIC30F4011). In order to maintain a constant brightness of the output lights, it is necessary for the switch-on pulses to the triacs to be synchronised to the frequency of the mains supply.

To achieve this, the microcontroller uses the INT0 external interrupt pin, which is supplied by one side of the transformer's secondary winding. An interrupt can be triggered on a rising or falling edge of INT0. Now, a low level on INT0 is any voltage lower than about 1.5V, while a high level is considered to be anything above 3.5V.

We have a 5V supply, but a 7.5V secondary winding. This means that the triggers to INT0 (which is the microcontroller's zero detection interrupt) are asymmetrical. The measured duty cycle is about 42% rather than the expected 50%. The firmware corrects this asymmetry, adjusting the value of a phase counter to take account of this.

Compare Fig.2 (without software correction) and Fig.3 (with software correction). In the scope screen grab of Fig.3, the yellow trace is the output of the triac and the green trace is the trigger pulse.

You can see that the trigger pulse period is only 8.5ms, whereas for symmetrical triggering it should be close to 10ms (this is the 100Hz rate, which is twice the mains frequency in the UK) as shown in Fig.3.

User operation of the DSP Musicolour

The Musicolour has many settings that can be changed by the user. As mentioned, the preloaded default values

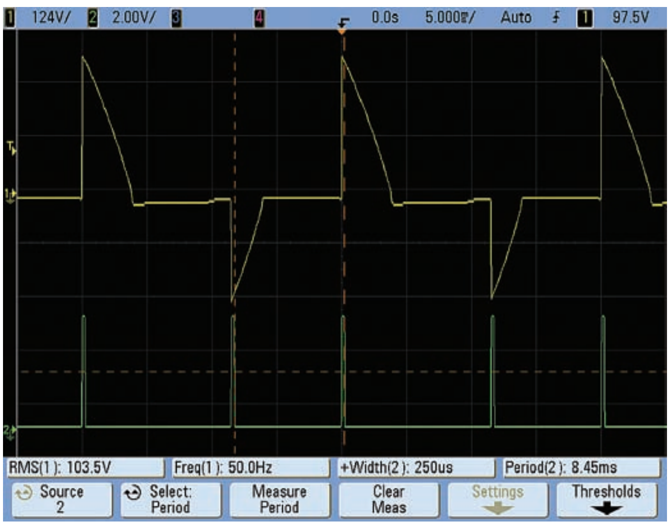


Fig.2: one of the physical output channels being switched without software correction for asymmetrical phases. The yellow trace is the output of the triac, while the green trace is the trigger pulse applied to the gate through the optocouplers.

You can see that the triggering is asymmetrical with a period of about 8.5ms, rather than the expected 10ms. Without software correction, the output brightness of the lights can vary and appear to flicker slightly.

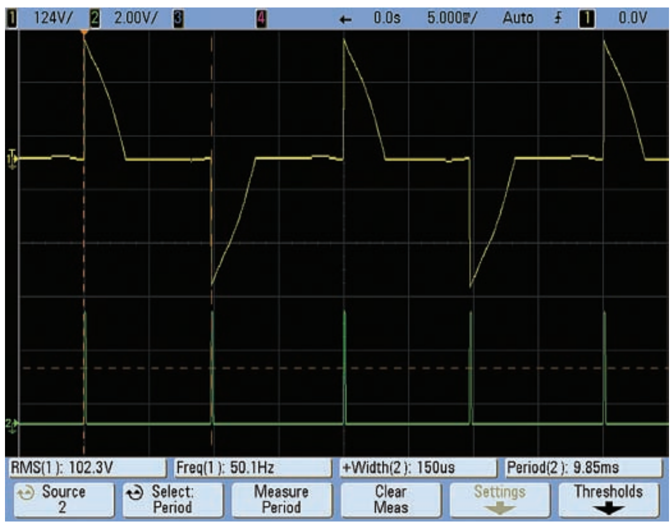


Fig. 3: the same set up as in Fig.2, but with software correction. The period is now much closer to the correct value of 10ms.

The firmware automatically corrects this asymmetry when driving the triacs. It does so in real time at a frequency twice the mains line frequency. Symmetrical triggering is desirable because it helps to maintain a stable and constant brightness on the physical output channels.

should be adequate for most applications. You can go to the *EPE* website and download more complete user instructions for the DSP Musicolour that were too long to include here.

Front panel

There are seven pushbuttons on the front panel that are used to navigate through the menus and change internal settings. Some buttons have multiple functions, according to context. The SELECT potentiometer is also context-sensitive, and is used to change settings.

The incorporated LEDs in each of the buttons will light depending on the context. Usually, a lit or flashing button will mean that the button has an active function in the current menu. When the firmware is executing the main loop, the LEDs will indicate the state of the output channels and the current operating mode.

Adaptive potentiometer controls

The DSP Musicolour firmware implements adaptive potentiometer controls. This means that if a setting is to be modified using the SELECT potentiometer, the setting will begin to change only when the potentiometer position first matches the current value of the setting. This gives the potentiometer a kind of memory, and is used to seamlessly change internal settings depending on the current menu.

Menu system

The settings of the DSP Musicolour are changed through a hierarchical menu system. When it is in the main loop, pressing the SET button allows you to enter MENU mode.

Keep in mind that some of the behaviour of the Musicolour is dependent on its current settings. For example, the display will be blank if the screen saver has been set to NONE and there is no key activity for the period of the screen saver timeout.

Using the Chaser Modes

Go to the CHASER>Mode submenu. Here you can choose Normal or Triggered modes. In NORMAL mode, the currently selected Chaser program is executed. In TRIGGERED mode, the currently selected Chaser program is executed, but the stepping through the program depends on the trigger (affected by the music).

If you are using TRIGGERED mode, you should know that the triggering will depend on the current settings for the trigger channel. Go to the TRIGGER submenu. There you should set the pass-band and threshold. Set the mode to OFF to run the output channels from the FFT.

Once you have set the Chaser mode, you then select the Chaser Program that you wish to run by going to CHASER>Program.

Conclusion

As you can see, the DSP Musicolour offers an amazing repertoire of features – far too many to allow us to describe in detail here.

Next month, we plan to have more information on driving the DSP Musicolour, as well as an optional PC board that gives you complete remote control. What? A lightshow with remote control? You betcha!

Quick setup checklist

Here's how to set up the DSP Musicolour quickly, together with the relevant settings that will affect its operation:

1. Set the ADC system's sampling frequency: go to AUDIO>Sampling Frequency.
2. Set the mixing settings for the input signal: go to AUDIO>Balance.
3. Set the minimum and maximum frequencies for each logical output channel: go to CHANNELS>Min Freq and CHANNELS>Max Freq. Alternatively, go to CHANNELS>Freq to set a non-overlapping frequency mask.
4. Set the gain for each logical output channel: go to CHANNELS>Gain.
5. Set the mode for each logical output channel: go to CHANNELS>Mode.
6. Set the output connections of the logical channels: go to OUTPUT>Logical Channels.
7. Set the CHASER>Mode and CHASER>Program
8. Exit the menu system.

Tip: Every submenu has a Default option to reset all values in that submenu to default values.

Simple setup guide

Assuming you have a music source connected to an audio amplifier, connect the output terminals of your amplifier to the speaker terminals on the back panel of the DSP Musicolour.

Next, adjust the sensitivity of the Left and Right channels using the Left and Right potentiometers on the front panel.

Load default values by going to the menu. Press SET while in the main loop to be directed to the menu. Scroll down to the DEFAULTS submenu using the UP and DOWN buttons on the front panel. Press SET to enter the DEFAULTS submenu. Scroll down to 'Load Defaults' and press SET. This will restore all default values. Exit the menu system by pressing CH 4/D (the back button while in menu mode) and the DSP Musicolour should start running the main loop in Automatic mode. The output channels will respond to the music.

Remember that the DSP Musicolour has many user options. As a summary, you should know that:

(a) Each of the four physical output channels must be connected to a logical channel. Two physical channels can be connected to the same logical channel. Go to OUTPUTS>Logical Channels to set these.

(b) The input signal source is an arbitrary mix of the Microphone, Left and Right audio inputs. You set this in the AUDIO>Balance submenu.

(c) The inputs are sampled at the set sampling frequency. Go to AUDIO>Sampling Frequency to set this.

(d) For each logical channel, you should select its pass-band (the minimum and maximum frequencies). Only frequencies in the input signal that fall in this pass-band will affect that logical channel.

(e) For each logical channel, you can select the gain. The higher the gain the more sensitive the channel will be to pass-band frequencies in the input signal.

(f) For each logical channel, you should select its mode. This affects how the channel responds to level requests. Choose from PEAK or AVERAGE acquisition modes. These determine how the FFT data affects the level of the logical output channel. This level is interpreted differently according to whether the channel is in DIRECT, CONTINUOUS, ZV or STROBE mode. So you should choose one of these four modes as well.

User operating instructions: menu system

The Musicolour uses a hierarchichal menu system. From the main loop, press the SET button to enter the menu system. You will be directed to the main menu, where you may scroll up or down between submenus by using the UP and DOWN buttons. Use the SET button to enter a submenu. In any submenu, you may use the CH4/D button to go back to the previous menu (if you are in the main menu, you will be directed back to the main loop).

Submenus available in the main menu:

1. CHANNELS: this submenu allows you to change any settings related to the four logical channels.
2. TRIGGER: this submenu allows you to change the trigger passband and the trigger threshold.
3. CONSOLE: this submenu contains user applications, allowing the Musicolour to function as a light dimmer or communications terminal.
4. OUTPUT: this submenu is used to set the chaser mode, the chaser program, the output rate, the quiescent level of each physical channel and to define the logical to physical channel translation.
5. AUDIO: this submenu is used to change the equaliser settings, the software mixing/balance of the input signal and the sampling frequency.
6. DEFAULTS: this submenu is used to save and recall settings and to load default values.
7. ADVANCED: this submenu is used to access advanced features, including calibration, software upgrade and tuning.
8. INFORMATION: this submenu displays information about the Musicolour's operation, such as the mains frequency, the frequency of the ADC system and the screen refresh frequency. The error in the overall accuracy of the timing system can also be seen.
9. DISPLAY: this submenu is used to change the display's settings, including the screen refresh frequency, the screen brightness and the screen saver time out period.
10. SYSTEM: this submenu can be used to change system settings, the firmware version is displayed, the baud rate of the UART can be changed, the remote control system can be enabled and other system settings changed.

Here are the major submenus used at this stage:

CHANNEL submenus:

CHANNELS>Min Freq: Press the channel buttons CH1-CH4 to display the current minimum frequency for that logical channel; Use the SELECT potentiometer to change the minimum frequency.

CHANNELS>Max Freq: Press the channel buttons CH1-CH4 to display the current maximum frequency for that logical channel; Use the SELECT potentiometer to change the maximum frequency.

CHANNELS>Freq: this is similar to the CHANNELS>Min Freq menu, except that after exiting, the minimum and maximum frequencies for the four channels are set in non-overlapped fashion.

CHANNELS>Gain: Press the channel buttons CH1-CH4 to display the current gain for that logical channel. Use the SELECT potentiometer to change the gain.

CHANNELS>Mode: Press the channel buttons CH1-CH4 to display the current mode for that logical channel. Use the UP and DOWN buttons to scroll through the available modes.

CHANNELS>Attack: Press the channel buttons CH1-CH4 to display the current attack rate for that logical channel. This is only relevant when the channel is operating in CONTINUOUS mode. Use the SELECT potentiometer to change the attack rate.

CHANNELS>Decay: Press the channel buttons CH1-CH4 to display the current decay rate for that logical channel. This is only relevant when the channel is operating in CONTINUOUS mode. Use the SELECT potentiometer to change the decay rate.

CHANNELS>Test Channel: Press the channel buttons CH1-CH4 to test the relevant logical channel with a range of output level requests from 0 to full level. This can be used to test the current settings for the channel.

CHANNELS>Defaults: Press SET to restore default CHANNEL submenu values.

TRIGGER submenus

TRIGGER>Min Freq: Press the UP and DOWN buttons to set the minimum frequency defining the trigger pass-band. Exit using the SET button.

TRIGGER>Max Freq: Press the UP and DOWN buttons to set the maximum frequency defining the trigger pass-band. Exit using the SET button.

TRIGGER>Threshold: Use the SELECT potentiometer to change the threshold level for the trigger. Triggering will occur when the input signal has an amplitude component within the trigger pass-band that is greater than the trigger threshold. The level is indicated as a horizontal bar. Exit using the SET button.

TRIGGER>Defaults: Press SET to restore default TRIGGER submenu values.

CONSOLE submenus:

CONSOLE>Dimmer: Press the channel buttons CH1-CH4 to select the relevant logical output channel. Use the SELECT potentiometer to change the output level of this channel. Here the Musicolour functions as a four channel light dimmer.

CONSOLE>Com: The Musicolour enters an echo terminal mode. Received data from the UART is displayed on the display. The UART can be enabled using additional hardware.

OUTPUT submenus:

OUTPUT>Chaser Mode: the current chaser mode is displayed. Press the SET button to scroll to the next available mode.

OUTPUT>Chaser Program: the current chaser program is displayed. Press the UP and DOWN buttons to set the program. Press SET to exit.

OUTPUT>Output Rate: the current output rate is displayed. Use the SELECT potentiometer to change the rate. Press SET to exit.

OUTPUT>Quiescent Level: Press the channel buttons CH1-CH4 to select the relevant logical output channel. Use the SELECT potentiometer to change the quiescent level of this channel.

OUTPUT>Logical Channels: Press the channel buttons CH1-CH4 to select the relevant physical output channel (on the back panel). Use the UP and DOWN buttons to change the logical output channel associated to that physical channel. In Normal operation, you set CH1=1, CH2=2, CH3=3, CH4=4; if for example, you wish to have logical channel CH1 control two physical outputs on the back panel, you could set CH1=1 CH2=1 CH3=3 CH4=4; If you would like to permute the channels you can also do that here.

OUTPUT>Defaults: Press SET to restore default OUTPUT submenu values.

AUDIO submenus:

AUDIO>Equalizer: The current equalizer settings are shown as vertical bars. Use the UP

and DOWN buttons to scroll to the next setting, and use the SELECT potentiometer to vary the current equalizer setting.

AUDIO>Balance: the current percentages of each of the three audio channels contributing to the input signal are shown. Press SET to change these. The levels are then displayed as bars. The first bar from the left is the MIC line level. The next two bars indicate the LEFT and RIGHT levels respectively. Use the SELECT potentiometer to change the LEFT/RIGHT balance. Use the UP and DOWN buttons to change the MIC contribution to the input signal.

AUDIO>Sampling Frequency: the current sampling frequency in kHz is displayed. Press SET and use the SELECT potentiometer to vary this value.

AUDIO>Defaults: Press SET to restore default AUDIO submenu values.

DEFAULTS submenus:

DEFAULTS>Load Defaults: Press SET to restore all settings to default values.

DEFAULTS>Save Settings: Press UP and DOWN buttons to change the memory number to save to. Press SET to save all current settings to non-volatile memory.

DEFAULTS>Recall Settings: Press UP and DOWN buttons to change the memory number to load values from. Press SET to load all settings with previously stored values.

ADVANCED submenus

ADVANCED>Calibration: Press SET to automatically calibrate the Musicolour's internal fast RC oscillator against the mains frequency.

ADVANCED>Software Upgrade: Press SET to upgrade the firmware. This mode requires a functioning UART connection, which needs additional hardware.

ADVANCED>Tune Oscillator: Press UP and DOWN to change the internal calibrating value for the system clock. This value is updated by the automatic calibration above. You can manually adjust the value here.

INFORMATION submenus

There are no settings to change here. Only the values of certain system parameters are displayed. This is for operating information like the mains frequency, the screen refresh rate, the sampling frequency, the system clock, the error in the system timing from the ideal, etc.

DISPLAY submenus:

DISPLAY>Brightness: Press SET to change, using the SELECT potentiometer, the brightness of the display.

DISPLAY>Frequency: Press SET to change, using the SELECT potentiometer, the screen refresh frequency. Note that strange display effects can occur at low screen refresh frequencies. If this is the case, increase the frequency. Usually a level around 65Hz or higher is adequate.

DISPLAY>Timeout: Press SET and use the UP and DOWN buttons to select the timeout period for the screen saver.

DISPLAY>Screen Saver: Press SET and use the UP and DOWN buttons to select the current screen saver.

DISPLAY>Display Defaults: Press SET to restore all DISPLAY submenu defaults.

SYSTEM submenus:

SYSTEM>Version: displays the current firmware version.

SYSTEM>Uart: Press UP and DOWN to change the baud rate for the UART. This requires additional hardware.

SYSTEM>Remote Control: Press SET to enable or disable the remote control decoding. This requires additional hardware and can be used to control the Musicolour using an RC5 compatible remote control.

SYSTEM>IrDA: Press SET to enable or disable the IrDA decoding. This requires additional hardware and can be used to add a wireless infrared serial port. This can be used to send and receive data from a PC.

SYSTEM>Test: Press SET to run a test on the display, the output channels and the LEDs. Can be used to check that all these are working correctly.

SYSTEM>Detected Mains: this shows the detected mains frequency and is either 50Hz or 60Hz. It should match your area's mains supply frequency.

SYSTEM>Startup: Press SET to scroll through the start up modes for the Musicolour. The initial startup can be made quicker by disabling the normal boot-up messages.

SYSTEM>RF6: Press UP and DOWN to change the RF6 pin mode. This is an advanced feature that can be useful to debug any problems with the Musicolour. The RF6 output of the microcontroller is a digital output and is available at pin 9 of CON3 on the main board. The system clock frequency can be measured at this pin, as well many other internal operating frequencies like the screen refresh frequency and the ADC system frequency. You will not need to normally use this menu.

SYSTEM>Reset: Press SET to reset the Musicolour.

SYSTEM>System Defaults: Press SET to load SYSTEM submenu defaults.

In Depth Explanation of the Main Loop

In more detail the main loop is as follows:

1. The firmware waits until the internal ADC system signals that the buffer has been filled with digitised and software mixed audio data (while waiting all interrupts are active, including all timers, key press detection and display refresh interrupts).
2. Once a full buffer of data has been acquired, the Fourier transform is computed.
3. For each logical output channel, a level corresponding to the channel is computed. This may involve adjusting the output of the FFT with equalisation, it will depend, for each channel on its selected acquisition mode.
4. A request is made, for each logical output channel to set its output level to the previously computed level. The implementation of this step is dependent on the channel's current setting. If a channel should be accepting data from an active chaser program, the level requested in this step is ignored.
5. If a Chaser program is active, it is serviced by the virtual machine. This may involve the triggering channel if the program is in trigger mode. Any output level requests made by the chaser program are set. Again, the implementation of this step is dependent on the channel's current settings.
6. The display is refreshed according to the currently selected display.

1. Spectrum Fine: the spectrum is displayed on the display.
2. Spectrum Centered: the spectrum is display in centered mode.
3. Logical Channel Displayed Single: the output levels of each channel are displayed. The top horizontal bar indicates the first logical channel. The third horizontal bar from the top indicates the second logical channel. Similarly, the fifth and seventh horizontal bars from the top indicate the third and fourth logical channels respectively.
4. Logical Channel Display Averaging: same as 3 above, except every horizontal bar in between the output channel bars is the average of the previous and next bars.
5. RMS display: displays the RMS level of the input signal as an analogue meter.

6. The firmware updates any LEDs on the front panel and returns to step 1. It also responds to key presses.

Troubleshooting tips

Some solutions to common problems that may help you troubleshoot the DSP Musicolour.

Problem
You apply power and there seems to be no activity, there is no display.

Possible cause
Is the fuse blown? Have you installed a fuse?

Problem
You apply power and there is a sudden short of the mains supply (consequently the fuse blows or the circuit breakers/fuse in your home open). There seems to be a short of the mains supply.

Possible cause
This could be caused by incorrect link settings for LK1, LK2 and LK3 underneath the mains transformer.

Problem
One or both voltages at test points TP0 and TP1 are not at normal levels around +5V and +10V respectively.

Possible cause
One possible cause is that links LK1, LK2, LK3 are improperly set or omitted. Remember, these have to be installed according to the mains supply voltage. Install LK2 and omit LK1 and LK3 if you are using a 220-240V mains supply; install LK1 and LK3 and omit LK2 if you are using a 110-120V mains supply. These links are found under the mains transformer, so you may have to unsolder the transformer to change them. If you have erroneously configured these links for 110-120V operation while you are actually in a 220-240V region of the world, you will get double the intended voltage at test-point TP1. This can very easily destroy REG1 and cause further damage to the main PC board. Disconnect power immediately if the voltages at TP0 or TP1 are much higher than their intended values.

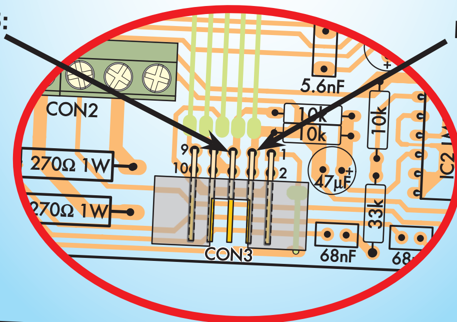
Troubleshooting in 'safety first' mode

If all goes to plan, you'll build the DSP Musicolour, turn it on . . . and it will work perfectly, first time. But what if it doesn't?

We've warned a number of times that the Musicolour must not be run with the lid off and the mains connected. It is simply too dangerous. So how can you work on an unpowered circuit?

Obviously, you can't. But fortunately, all of the logic and processing circuitry (including the dsPIC) can be run from a 5V DC supply (rated at 500mA or so) so you can troubleshoot with safety.

If you need to poke around the Musicolour, CON3 can be used to supply power to the circuit. Simply connect +5V to pin 5 and 0V to pin 3 of CON3 and all of the low-voltage circuitry will be powered, up to and including the four opto-couplers. DON'T plug in the mains lead!



Section of full overlay from the June 2010 *EPE*

Problem
The main board seems to be operating correctly, except nothing is shown on the dot matrix LED display.

Possible cause
The most common cause of this problem is that the 26-way ribbon cable connecting the main board and the display board is either faulty, not all connections are good, or it is incorrectly oriented. If you can verify that the ribbon cable's 26 connectors are good, it may indicate a fault with incorrectly oriented parts. Check the transistors and ICs are correctly oriented on the display PC board. Check also that the dot matrix LED modules are in their sockets the right way around.

Problem
At least one key does not respond to key presses or its LED does not light up.

Possible cause
This is most likely caused by the tactile switch being incorrectly oriented, improperly soldered, or its accompanying diode being incorrectly oriented.

Problem
When in a menu, moving the SELECT potentiometer does not affect the setting, or does so after much turning.

Possible cause
This is most likely not a problem, but a feature. It is called adaptive control. See the text for an explanation.

Tips and tweaks
Notice that if the display frequency is set too low you may see strange effects on the display. Increase the screen refresh frequency if this occurs. Also, if the sampling frequency is lower than twice the highest frequency of the input audio, aliasing will occur.

What about the Musicolour Display – the lights!

By Ross Tester

The DSP Musicolour is capable of driving up to 2400W of lights over its four channels, with a maximum of 800W in any one channel.

That's an awful lot of coloured light – far more than you'd normally find at a party, which tends to be on the dark side anyway.

Let's look at the type of lights you can use (and shouldn't use).

First of all, steer clear of halogen (QI) lights. Their problem is the time the filament takes to cool and the light to go 'out'. They also get very hot and this can be a problem with coloured films – depending on the type, they scorch with high temperatures and can even catch fire. That's about the last thing you want.

By far the most popular display/party lights are the coloured ES (Edison screw) PAR38 or R80 bulbs. The coloured PAR38s are usually rated at 120W (their plain white cousins are usually 150W, some 120W).

Incidentally, just in case you wanted to know, PAR38 means Parabolic Aluminised Reflector, 38 eighths of an inch (or 4.75 inches) in diameter. R80 means an 80mm diameter reflector light globe. So there!

The biggest (money) problem with coloured light globes is the price – they are significantly more expensive (about four times or more) than white ones. But I have a sneaky solution here: paint white globes and save heaps!

You can't use ordinary paint, of course – it is opaque. But you can buy translucent glass paint at better craft stores in a wide variety of colours. The most common colours for light displays are also the easiest to get – red, yellow, blue and green.

This paint is intended for making (fake) 'stained glass' windows, but I've found it to be quite tolerant of high temperatures, so it can be painted directly onto white globes. The brand I use is Vitrail, from France. But I've also seen other brands of this type of paint advertised on eBay (just make sure it is translucent/transparent when dry).

I've used it for years instead of buying coloured globes and it works very well. You simply paint it on so that the glass has an even covering; usually only one coat is required.

Allow it to dry before turning on the light – even then, you're likely to get some coloured vapours given off and it does tend to stink a little! If I'm in a real hurry, I might apply a little heat from the light globe – say ten seconds on, a minute off – to impart a little forced drying.

OK, so that's the coloured globe side covered. Now, how about their mounting?

Simple, I thought: just go and buy some ES batten lampholders, mount them on a length of flat timber and wire them up. Yeah, simple all right: have you seen the price of ES battens recently?

You can get a standard BC (bayonet cap) batten lampholder for a few pounds just about anywhere. The same things in ES (Edison screw), which are required for the PAR38 and many R80 bulbs, tend to start at around a tenner and go up from there.

But, I 'cheated' here too. In our local hardware store, I spotted a PIR movement detector security light, complete with two ES lampholders and two 150W PAR38 bulbs, all for under a tenner. So I bought two of these, giving me four ES lampholders and four PAR38 bulbs.

I discarded the two PIR sensors (anyone know what to do with two brand new PIR sensors?) and mounted the two sets of two ES lampholders on a length of flat timber and wired them (individually) to short 240V mains leads.

Even here I was able to save, by using old 240V leads. Call it the scrounger in me, but every time I discard any electric appliance, if the mains lead is OK I cut it off and save it – just in case. Well, here's the case and phhhhttt to all those who have criticised me for hoarding rubbish saving and recycling perfectly good stuff!

In fact, I used two such salvaged mains leads and two old IEC mains leads, which had also been saved from the scrapheap (actually rescued from the last council clean-up). The IEC plugs themselves were not needed (not now, at least!) so I cut them off with maybe 250mm of mains lead attached (just in case!) and put them back in my 'spare mains lead' box. You never know. . .

That gave me four mains leads, complete with three-pin plugs, about 1.5m long. Perfect!

I've shown a photo of my 'cheapo' Lamp Display Unit above. While this is very obviously only one approach, it gives you an idea of what you can do to make a very reasonable lightshow for a very reasonable price.

The ES bases even have some very handy terminal blocks inside, so wiring them up is delightfully easy. Each light operates completely independently to any other, so all are wired separately.

Remove the wires from the PIR unit and discard it. Connect the mains (brown wire) in one of your mains leads to the white wire going to the lampholder, the neutral (blue) to the blue wire and the earth (green/yellow) to the green/yellow wire in the terminal block.

Repeat for the second mains lead and ES base, then fasten the mains leads under the anchor strip provided (there is just room). Screw the assembly onto a suitable piece of timber. Put the top on, screw it all up and put your two PAR38 bulbs into their holders. Connect both mains plugs to a suitable outlet to ensure both lights work.

Repeat all this for the other ES base assembly, check it – and you're ready to plug it into your DSP Musicolour and light up your life. Oh, you did remember you had to build the Musicolour first?

How To Solder SURFACE-MOUNT DEVICES

Many electronics enthusiasts hesitate to build projects involving surface-mount devices (SMDs) because they're 'scared' by the prospect of soldering such tiny parts to a PC board. But it can be done; Jim Rowe shows how.

IT'S TRUE THAT SMDs are not really intended for manual assembly. They're designed for automated pick-and-place machines and reflow soldering ovens.

The problem is that more and more ICs and other components are becoming available ***only*** in SMD form. As technology marches on, it's becoming necessary for everyone to get used to working with SMDs.

You may already be familiar with simple SMDs, like resistors, capacitors, diodes and transistors. Some of these are shown in Fig.1. Note that they're all shown **twice** actual size, for clarity.

We've used these in various projects published in the last few years, and shown how they can be soldered onto a PC board: use a soldering iron with a fine conical or flattened conical tip and very fine (0.71mm OD) resin-cored wire solder.

How this is done is shown in Fig.2 and Fig.3. The basic idea is to hold the chip or device in place while you tack-solder one or two of its leads to hold it in position. This then allows you to solder all the leads to their pads in the usual way.

It needs to be done very carefully and fairly quickly, so you don't damage either

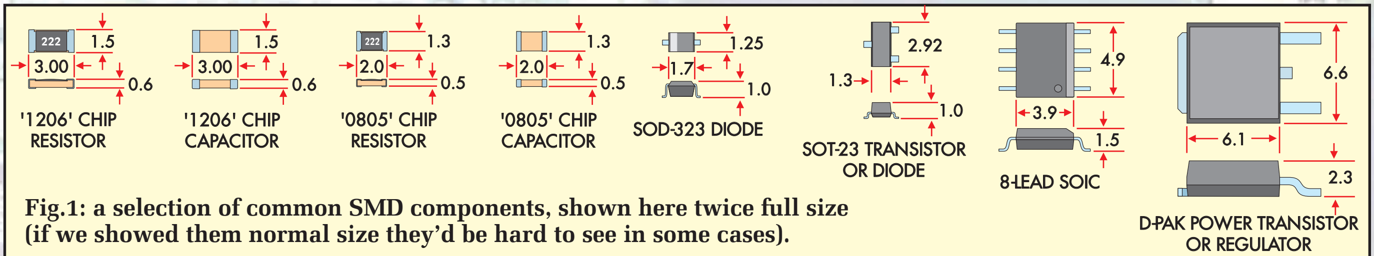


Fig.1: a selection of common SMD components, shown here twice full size (if we showed them normal size they'd be hard to see in some cases).

the SMD or the PC pads by overheating. You also need to make sure you don't apply too much solder, which can cause fine solder 'bridges' to short between copper pads or tracks.

If you do get solder bridges, they can be removed by applying the end of some fine desoldering braid to the top of the 'bridge' and briefly applying the tip of your soldering iron to the top of the braid, so the end of the braid heats up to the solder's melting point and 'sucks up' the excess solder by capillary action.

OK, so what is the real problem with SMDs? Put simply, it's not the resistors, but the large SMDs with umpteen dozen closely spaced pins.

Fine-pitch ICs

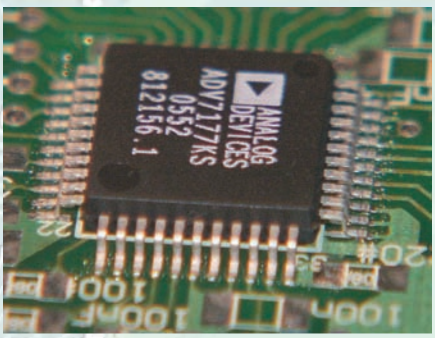
More and more VLSI (very large-scale integration) devices now come in SMD packages, like the one shown opposite and those in Fig.4 – quad flat packs (QFPs) with anywhere between 44 and 208 leads (pins).

The lead pitch can be as fine as 0.4mm – less than 16% of the 0.1-inch/2.54mm pitch used in most familiar dual in-line IC packages.

The width of the leads can also be as fine as 0.18mm (that's right – only 180μm!), so the actual spaces between the leads can be as small as 0.22mm or 220μm.

Now it *is* possible (just) to solder a 44-lead MQFP device with 0.8mm pitch leads like the IC shown in Fig.4, using a fine-tipped soldering iron and the technique shown on the right in Fig.3.

That's providing you are extremely careful, have a very steady hand and don't mind having to use the soldering braid to remove the almost inevitable solder bridges. If you can do this consistently, then you are a champion!



Close-up view of a 44-lead MQFP device with 0.8mm pitch (lead spacing), after being reflow soldered using a low-cost snack oven.

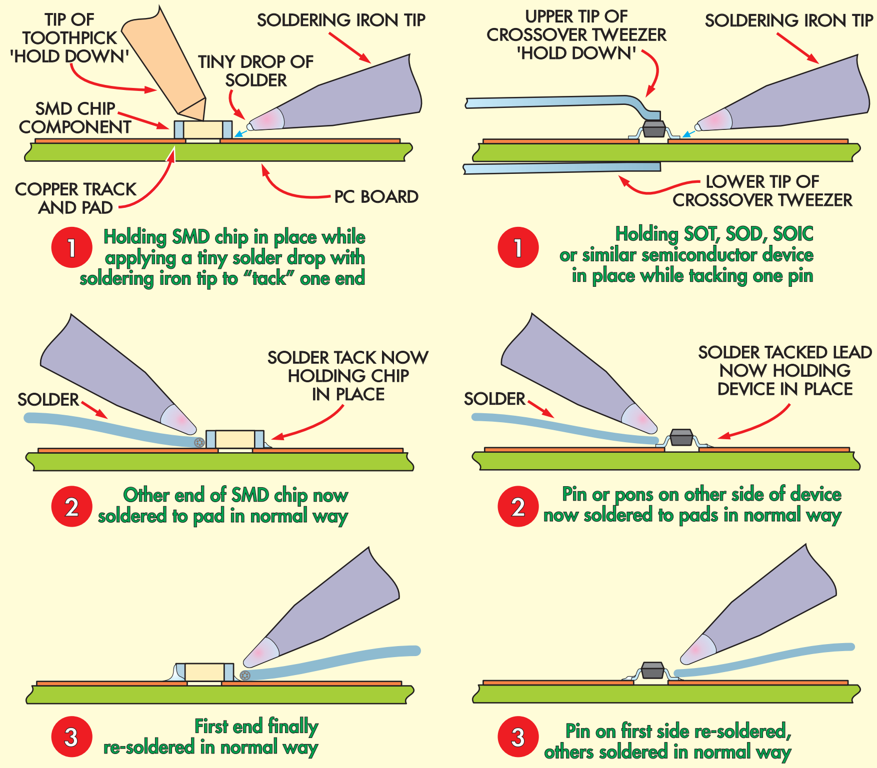


Fig.2: the basic steps involved in manually soldering smaller SMDs like those shown in Fig.1, using a fine-tipped soldering iron and very fine resin-cored wire solder. The steps for resistors and capacitors (left) are much the same as those for SOT, SOD and SOIC devices (right).

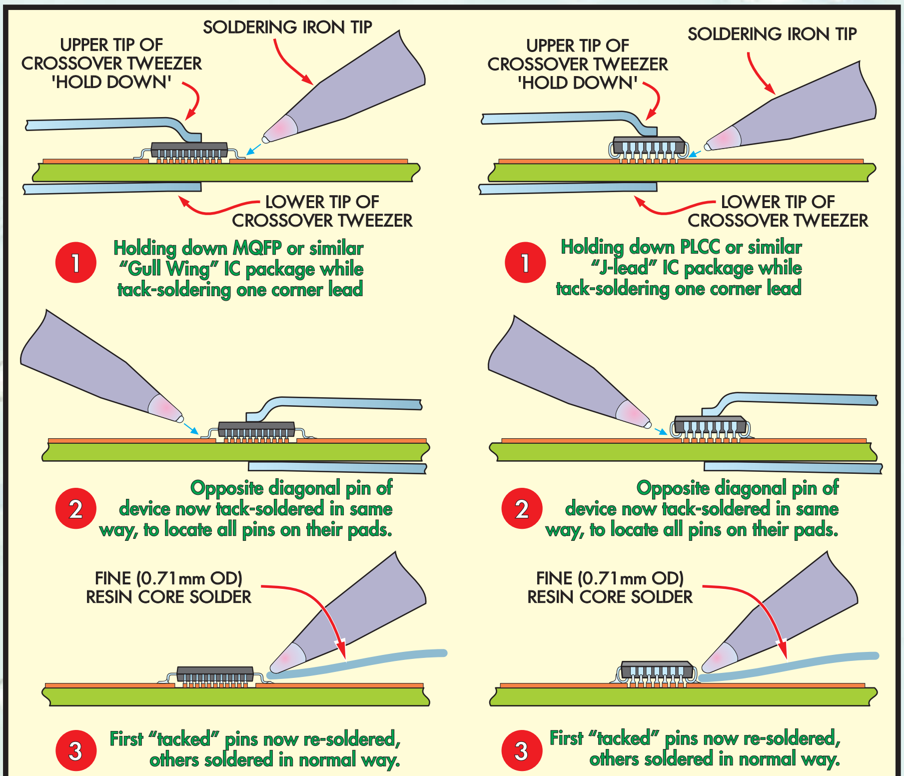


Fig.3: manual soldering of SMD ICs with lead pitches of 0.8mm or more can be done in the same way if you're VERY careful, but be prepared for the accidental creation of solder bridges between leads – and having to remove them using solder wick. As you can see, there's not much difference in approach between 'gull wing' and 'J-lead' devices.

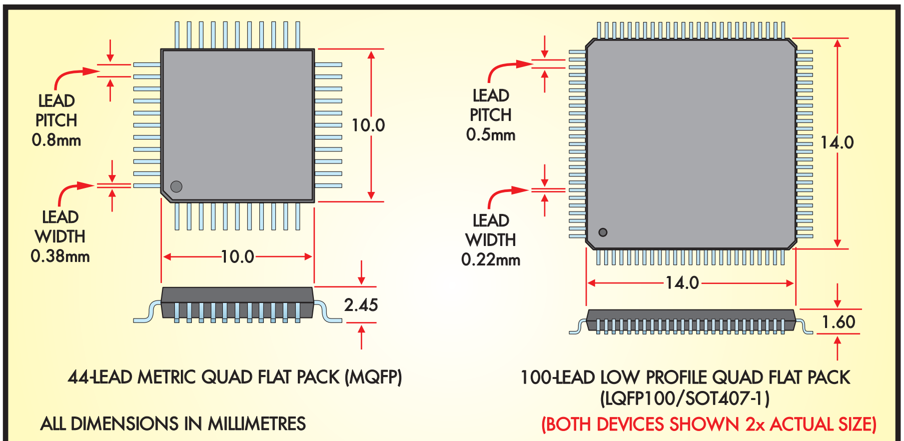


Fig.4: the key dimensions of a 44-lead MQFP device compared with those for a 100-lead LQFP device – both shown twice actual size for clarity. You can see why the fine-pitch devices can't be soldered manually or even by wave soldering.

The real problem arises when it comes to devices with lead pitches of 0.4mm or 0.5mm, like the 100-lead LQFP device shown in Fig.4. These packages are not even suitable for automated wave soldering, let alone manual soldering. The leads and gaps between them are just too narrow.

Reflow profile

The only way to solder these devices is by reflow soldering. This process involves applying solder paste to all of the tiny copper pads on the board (using a laser-cut stencil and squeegee system), then placing the SMDs accurately in position on the board. Once the SMDs are in position, the boards are then placed on a conveyor belt and passed through an 'IR reflow oven' at a controlled rate, using infrared radiant heating.

Inside the oven, they move through areas with temperatures set for preheating, followed by a 'ramp up' to above the melting point of solder and then a 'ramp down' to well below the melting point. This is known as a 'reflow soldering profile'.

Using this approach, SMDs with a lead pitch of 0.4mm can be soldered to boards safely and with a high degree of reliability, at the same time as all of the other SMD components.

The main drawback is that a commercial IR reflow oven is very expensive (many thousands of pounds) and thus beyond the reach of enthusiasts and even many small manufacturers. Getting laser-cut solder paste stencils made from your PC board CAD file is not cheap either.

So, the challenge is to find a much cheaper way of soldering these fine-pitch SMDs on to PC boards. Fortunately, there is a way!

About solder paste

Solder paste is available from the better electronics stores. It consists of tiny spheres (<50μm in diameter) of tin-lead solder (63% tin, 37% lead), suspended in a water-soluble paste or gel of flux.

It's typically sold in fairly large plastic syringes, holding about 80 grams of solder paste. This is actually far too much for the average enthusiast, because the ingredients in the flux apparently have a shelf life of only six months after manufacture, even when stored in a refrigerator. Yet 80g of paste is enough to solder many hundreds – even thousands – of SMDs.

So, while solder paste is available, it's a pity that it isn't sold in much smaller quantities – say 5g or 10g, resulting in a lot less wastage.

When you buy solder paste, make sure you store it in a refrigerator so you'll at least maintain its six-month working life. Do ***NOT*** store it in a fridge that is also used to store food. If you must, place the syringe in an air-tight container, because both the solder spheres and the flux give off toxic fumes – see later.

Applying the paste

As mentioned earlier, large-scale manufacturers use laser-cut stencils and a squeegee system to apply just the right amount of solder paste to every pad on the PC board where an SMD lead or contact area is to be soldered.

This is shown in the upper two diagrams of Fig.5. This technique simply isn't practical for small manufacturers or enthusiasts.

A much simpler approach involves applying a thin 'stripe' of paste along the pads for the SMD leads, as shown in the lowest diagram in Fig.5.

The stripe of paste is only a millimetre or so wide and can be applied using a fine brush, a very narrow roller applicator or a fine spatula with a 1mm wide tip.

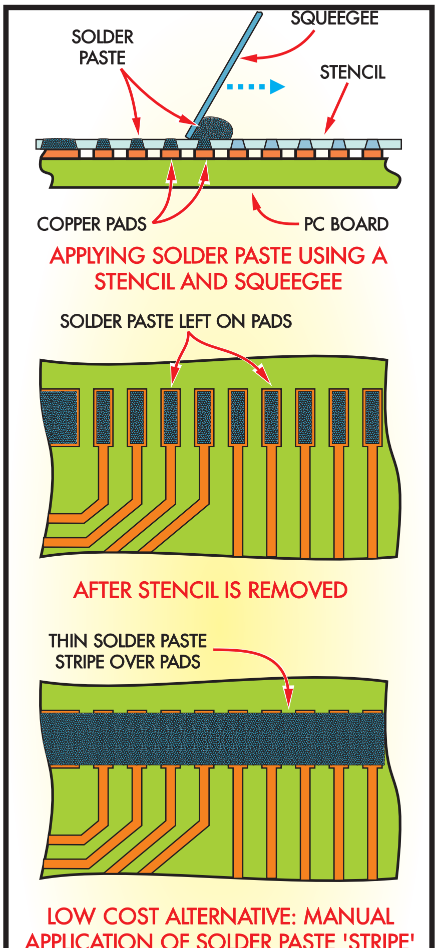
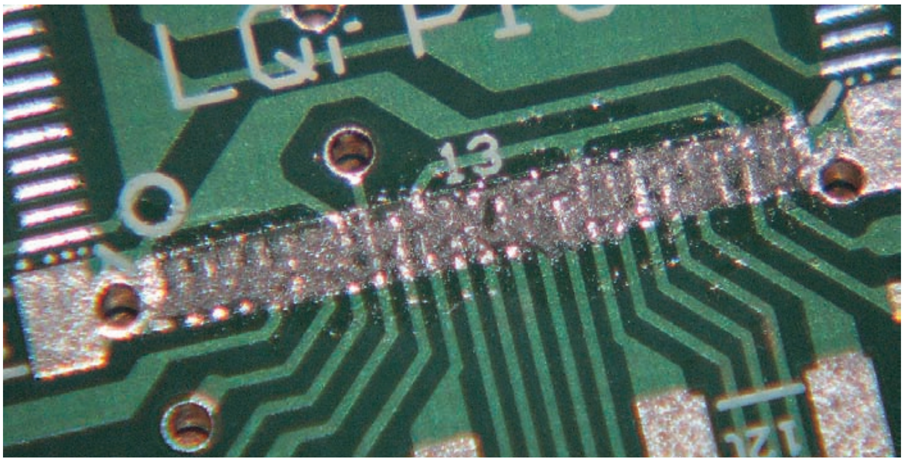
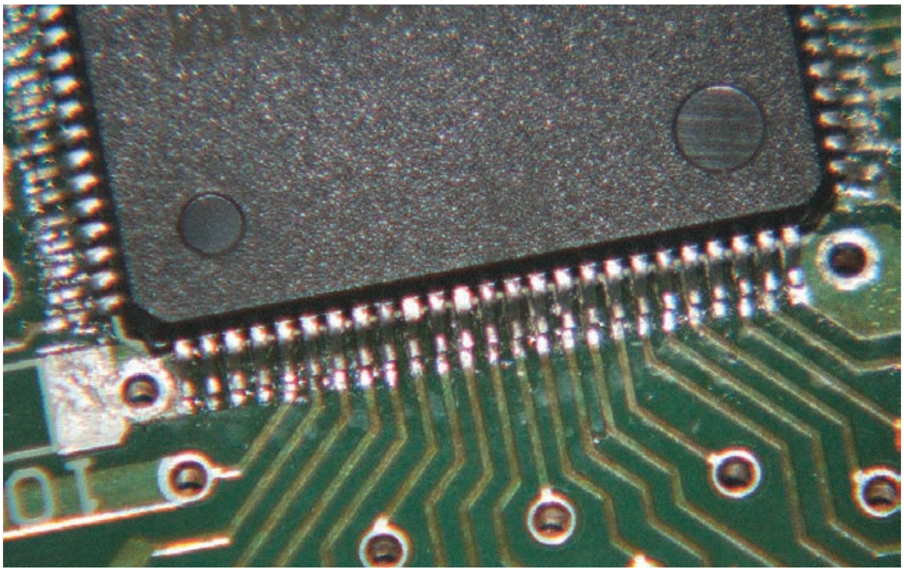


Fig.5: for reflow soldering, large-scale manufacturers apply solder paste to the board pads using a squeegee and a very thin stencil, laser cut from the PC board CAD file (top). This leaves the paste neatly on the pads (centre) but this is not feasible for enthusiasts. However, for fine-pitch SMDs, a very thin paste stripe (bottom) is almost as good.



Above: a close-up view showing a thin 'stripe' of solder paste applied manually to the pads for one side of a 100-lead LQFP device, with the tiny solder spheres just visible. This stripe is a tad uneven in thickness – a little too thick near the left end, and a little too thin towards the centre.



A close-up of the same board after the device had been reflow soldered using a snack oven. Despite the 0.5mm lead pitch, there were no solder bridges.

You'd think that applying a continuous stripe of solder paste in this way would be asking for trouble because it would form bridges between pads, during the reflow soldering process. However, the secret of this approach is to make the paste stripe very THIN – only about 100μm wide or two solder spheres thick.

If it's no thicker than this, the result is that surface tension and capillary action cause the solder spheres to 'pull themselves together' into the gaps between each SMD lead and its board pad, when they melt during the reflow soldering. As a result, most of the solder spheres in the paste between the pads get sucked into the molten solder directly under each SMD lead, leaving very few to form bridges.

Not too thick, not too thin

If you make the paste stripe too thick, there WILL be enough spheres left in the gaps between pads to form bridges.

On the other hand, if you make the stripe too thin, there will be insufficient spheres to pull together and form a good bond between each SMD lead and its pad underneath. So, erring in this direction results in 'missing joints' after the reflow soldering process – not at all easy to repair!

The most important thing about this manual approach to applying the solder paste is to take your time and to make the stripe width as you can. It's easiest to do this with the board under a magnifier lamp or even a low-power stereo microscope with illumination.

I've also found that a very thin and narrow-tipped (about 1mm) spatula seems to make it easier to apply and even-up the paste stripe, although a very narrow 'applicator wheel' (I made one myself) was almost as good and much easier than a fine brush.

Whatever you use, the main ingredient is time and patience – applying solder paste is a bit like trying to spread microscopic caviar evenly on a sheet of glass.

In fact, since you have plenty of paste, do a few dry runs on a sheet of PCB copper laminate.

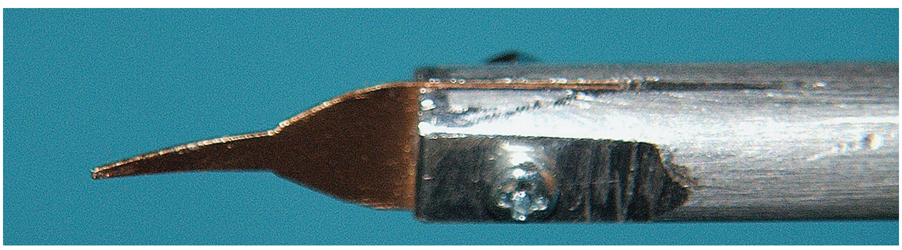
Placing the SMDs

Once the solder paste has been applied to the board, you can place your fine-pitch SMD(s) in position, with their leads over the board pads, ready for the reflow soldering process.

Large-scale manufacturers use a pick and place machine to position all of the components on the board in one pass – not just the fine-pitch SMDs, but everything else as well. Then all parts can be soldered to the board in a single pass through the reflow oven. But that's not really feasible if you're placing all of your components manually.

Our method is to place the fine-pitch ICs on the board first, then do their reflow soldering. After the board cools down you can then inspect the results, and if all is well you can proceed to solder in the rest of the components one by one, using the fine-tipped soldering iron approach illustrated in Fig.2 and Fig.3.

You may be wondering how accurately you have to place the fine-pitch IC packages in position, before reflow



The business end of a 'mini spatula' made by the author for applying a stripe of solder paste on pads for fine pitch SMDs. It's shown here about 3× actual size.

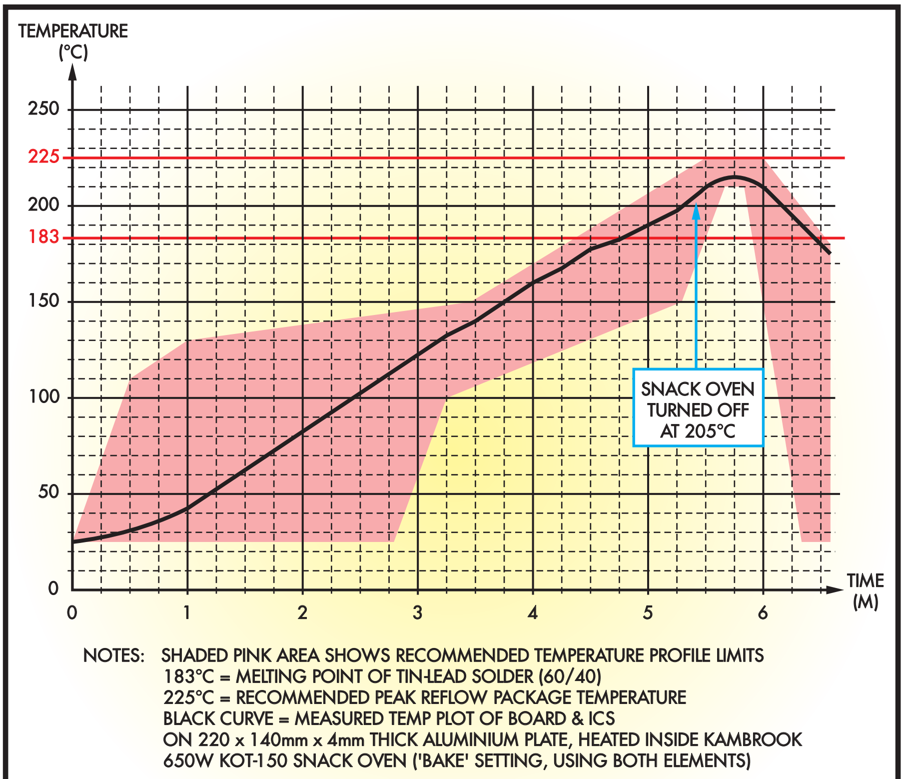


Fig.6: the shaded pink area shows the reflow soldering temperature profile limits recommended by SMD manufacturers. The solid black curve shows the measured temperature plot achieved using a low-cost snack oven set on 'Bake'.

soldering. The answer is placed fairly accurately, but not fanatically so. The main thing is to make sure that every device lead is over its corresponding PC board pad and closer to that pad than it is to any other pads nearby.

If you achieve that, when the solder spheres in the paste melt and coagulate during the reflow process, surface tension and capillary forces in the molten solder will automatically 'pull' all the leads centrally into position over their pads.

So, the idea is to carefully lower the IC package (orientated correctly, of course) into position using a 'vacuum pick-up tool' or similar, and then nudge it gently into the correct position using a fine jeweller's screwdriver or pick tool. Again, it's easiest to do this under a magnifier lamp or stereo microscope, preferably one where you can rotate the board and IC until you're happy that all leads are over their pads on the board.

Once all the fine-pitch SMDs have been placed carefully in this way, your board will be ready for reflow soldering. Be very careful not to bump or jar it, because the SMDs could easily be jolted out of position.

Reflow soldering

Now, how do we do the actual reflow soldering? If you use an online search engine to track down info on reflow soldering, you'll find that quite a few people have tried doing it with an electric frypan or skillet.

The basic idea is to place the PC board in the centre of the frypan, applying power until the solder paste clearly melts and flows under each SMD lead. You then turn off the power and allow it all to cool down.

This can work – but there is a big risk of scorching the underside of the PC board; inevitably the underside of the board must be raised to a temperature considerably higher than the melting point of solder.

This board-overheating problem tends to be made worse because the heating element in the underside of most frypans is circular in shape. This produces uneven heating of the PC board, with a cooler region in the centre, surrounded by a ring of heat.

So, depending on the location of your fine-pitch SMDs on the board, the reflow operation can easily result in a ring of scorching on the underside of the board. The result is a totally unusable board, and the SMDs won't be salvageable either.

Get an old frypan

If you decide to try the frypan approach, ***please don't use a frypan that is also used for cooking food***.

The fumes given off by solder paste during the reflow process are quite toxic and are likely to be absorbed by the frypan metalwork and/or Teflon coating. So the toxins may well be transferred into any food cooked in the frypan afterwards.

Buy a cheap frypan specifically for the job, and mark it clearly **'NOT TO BE USED FOR COOKING FOOD'**.

Because of the toxic fumes given off during reflow soldering, it's also very desirable to do it in a well-ventilated area – preferably outdoors. This applies regardless of whether you use a frypan or some other heating device.

Having read the references on the web about reflow soldering using a frypan, I decided to try it, but with a slightly different approach.

I bought a cheap frypan, then did a few experiments with it. To try getting around the board scorching problem, I cut a 'heat spreader' plate from 4mm thick aluminium sheet and placed this in the centre of the frypan with my test board sitting on it.

This did seem to make the heating fairly even, but there was still a major problem. Even with the frypan's thermostat set for maximum, the temperature on the top of the PC board never reached the melting point of solder (183°C), let alone the 215° level that is necessary to ensure good reflow.

Presumably, the small air gap between the bottom of the frypan and my spreader plate added too much thermal resistance. I removed the spreader plate and tried again, with the board placed directly on the bottom of the frypan.

This time the temperature on the top of the board did reach about 210°C and reflow took place. However, when it had cooled down, I noticed that the underside of the board had been scorched in areas that had been directly over the circular heating element.

So, reflow soldering with a frypan is just not worth the risk of PCB damage.

In the oven

Another 'cheapo' reflow technique that you'll come across on the web

involves the use of a small electric 'snack' or toaster oven. Almost all these use a pair of heating elements, one at the top of the oven compartment and the other at the bottom.

Whatever you're going to heat up in the oven goes on a tray supported by a wire mesh 'drawer' in the centre, which is linked to the oven door so it slides in or out when the door is closed or opened.

Often, there's a switch which allows you to select either the top element (Grill) or the bottom element (Reheat) or both at the same time (Bake). Each element draws about 325W, so the oven uses about 650W when both are used together. Since the reflow operation only involves drawing this power for five or six minutes at most, this isn't a problem.

The main advantage of using this kind of snack oven for reflow soldering is that the heating is done by infrared radiation, on the top of the board as well as from below, just like a 'proper' IR reflow oven. The main difference is that your board stays fixed in the oven during the whole process, rather than moving through different temperature regions on a conveyor belt.

This means that you have to arrange for the reflow temperature profile to be provided in some other way. This turns out to be easier than you would think.

I decided to try the snack oven approach for myself, so I bought a Kambrook KOT-150 snack oven which cost just £20. It has no thermostat – just an electromechanical timer and the element selector switch. But the lack of a thermostat is not a problem, and the timer didn't turn out to be all that necessary either.

First bake

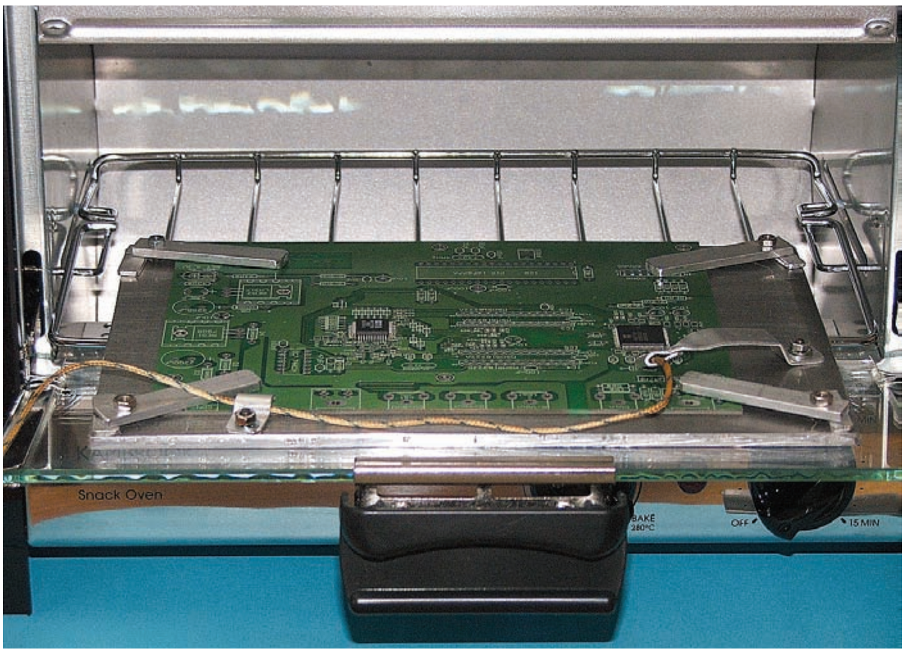
My first test with the snack oven was to clamp a thermocouple temperature probe onto a test board, which was then placed in the small pressed tinplate tray that came with the oven. The tray was then placed on the oven's sliding mesh drawer and the oven door closed carefully so that the thermocouple lead could exit through a small gap at the top of the door.

The oven was set to 'bake' (both elements on) and the timer knob set to apply power for about 10 minutes. I then proceeded to take temperature measurements every 15 seconds.

Here's the setup we used to successfully reflow solder fine-pitch SMDs. The board assembly is clamped on a 220 × 140mm plate of 4mm-thick aluminium plate, with a thermocouple probe clamped to the board copper near the 100-lead device. Shortly after this shot was taken the snack oven was turned on and then turned off as soon as the digital thermometer reading hit 205°C.

The resulting temperature characteristic turned out to be very close to the solid black curve in Fig.6, which also shows (shaded pink area) the reflow temperature profile limits for fine-pitch SMD IC packages recommended by chip manufacturers like NXP/Philips.

As you can see, the warm-up characteristic is nicely within the recommended limits. By turning off the power to the oven when the temperature on the top of the board just reached 205°C, the board temperature coasted up nicely to a peak of 215°C and then began to coast down again. It



As soon as the temperature coasted down to about 165°C, the door of the snack oven was carefully swung down to allow the entry of more air to speed up the cooling. Both SMDs on this board had been reflow soldered very nicely, with no solder bridges between leads or pads. The board had not been damaged in any way either, so we can recommend the snack oven approach.

It's not elegant but it works: an SMD chip baking oven, made by converting a discarded blower heater. The reflector part of the heater was flattened and bent into a small rectangular oven shape, then re-attached to the front of the blower heater element (just visible through the opened front door).

dropped down below the 183°C solder melting point temperature about 6.5 minutes after switch-on, so after waiting about one more minute, I carefully opened the door and drawer to allow cooling to occur more rapidly.

When the test board had cooled right down, I took it out of the tray and checked underneath to see if there had been any scorching. There was none at all – even the silk screen printing on the underside of the board showed no discolouration.

Trial run

Encouraged, I decided to carry out a reflow soldering test on another PC board. This was prepared with solder paste stripes around the pads for a fine-pitch IC, and then an SMD device was carefully placed over these pads. It was here I made my first mistake.

In an effort to make the process a little more controlled, I drilled four 3mm holes in the oven's tinplate tray, so the board could be fastened into it using four M3 machine screws and nuts. One of the screws was also used to attach the clamp for the thermocouple probe, to hold the probe securely in position with its bead in contact with the board's top copper close to the SMD chip.

The board and tray were carefully placed on the oven's mesh drawer and the oven door gently closed so they slid smoothly inside. Then power was applied to the oven again and the top-of-board temperature was checked every 15 seconds as before.

All went well, with exactly the same temperature profile as before. But then, just as the temperature reached about 200°C (just before I would turn off the power), there was a 'ping' sound – apparently the tinplate tray had been under stress as a result of the board being bolted inside and the stress was relieved suddenly when the temperature reached 200°.

Having turned off the power as soon as the temperature reached 205°, I waited impatiently while the

Ten Tips for successful DIY reflow soldering of SMDs

1. Store your solder paste in a sealed container in a fridge, to prolong its useful life.
2. Take care to apply the solder paste in a 'stripe' along the centre of the SMD lead pads on the PC Board, with the stripe no more than about 1.5mm wide and (most important) very thin – no more than about 100μm or two solder spheres. As even in thickness as you can make it, also – no lumps or voids.
3. Use a small snack oven for reflow soldering. Clamp the PC board on the top of a flat heat diffusion support plate made from 4mm thick aluminium sheet, say 220mm × 140mm in size (to fit comfortably in the snack oven). Also monitor the temperature on the top of the board near one of the SMDs, using a thermocouple probe connected to a digital thermometer.
4. Place the SMD chip(s) in position on the board carefully, with all leads as near as possible to their corresponding board pad. You don't have to be fanatical about this though: the chips will auto-locate during reflow, providing each lead is closer to its own correct pad than to the pads on either side.
5. Place the board and its support plate on the oven's slide-out drawer very carefully, so as not to bump or jolt the SMDs from their positions. Then carefully close the oven door so they slide smoothly into the oven – again without jarring.
6. Use both the upper and lower heating elements of the oven for reflow solder heating. This is usually achieved by selecting the Bake setting. Using both elements gives more even heating, closer to that in a proper IR relow oven.
7. Switch on the oven, monitoring the temperature on the top of board using the thermocouple probe and digital thermometer. The temperature should rise fairly smoothly, reaching the melting point of tim/lead solder (183°C) in just under five minutes. Take care not to bump or jar the oven after this.
8. As soon as the temperature reaches about 205°C, turn off the oven power without bumping anything. The temperature will continue rising, to reach a peak at around 215°C to 220°C. It should then begin falling again.
9. Wait until the temperature drops below the melting point of solder – say down to about 165°C. Then it should be safe to open the oven door so the drawer and its contents slides out, to speed up further cooling.
10. When the board has cooled down to around room temperature, remove it from the support plate and check the solder joints on all SMD leads with an illuminated magnifier or stereo microscope. If there are any solder bridges, these can be cut away using the tip of a hobby knife or 'sucked' off using desoldering braid and a fine-tipped soldering iron.

temperature peaked again and crept downwards once more. Once it had dropped to about 165°C I carefully opened the door, so the drawer and tray slid outwards.

Then I examined the SMD chip with a magnifying glass, only to discover that the stress relief 'ping' at 200°C had caused the SMD chip to be jolted out of position. The reflow soldering had actually occurred quite nicely but with the chip and its leads in the wrong position.

On the plate

However, the overall result still confirmed that the snack oven was quite suitable for reflow soldering. I decided to make a much sturdier PC board support plate, to replace the flimsy tinplate tray. The new plate was a 220 × 140mm rectangle of 4mm-thick aluminium plate and had a 3mm hole drilled near each corner, for the board hold-down clamp screws.

The holes were countersunk underneath so that countersink-head screws could be used to hold down the board, without producing bumps underneath the plate. This was to make sure that the plate and board could be moved smoothly on the oven's mesh drawer.

Another board was prepared with solder paste and a fine-pitch SMD chip placed carefully in position. Then the board was clamped to the top of the new support plate, the thermocouple probe fitted and the complete assembly placed inside the oven.

This time, everything went really well. There were no 'pings', the solder reflowed nicely, and when it all cooled down again, a board inspection showed that the SMD chip had settled itself in the correct position and was nicely soldered. And there were no solder bridges!

So, we are able to report that reflow soldering of fine-pitch SMD chips can be done successfully using a low-cost snack oven like the one shown in the pictures. Listed on the page opposite are the 10 important 'rules of thumb' when it comes to using a snack oven to reflow solder fine-pitch SMD chips. If you follow these rules carefully, success is almost guaranteed.

Finally, what about using a 'fan-forced' snack oven? ***Not*** a good idea! The fan could easily blow the SMDs out of position! *EPE*

Footnote: About MSL Rating

If you're going to be using reflow soldering for SMDs in plastic packages, you should know a bit about the way these devices are rated in terms of MSL or 'moisture sensitivity level'.

Basically, it has been discovered that SMDs in plastic packages have a tendency to absorb moisture when they're stored in typical 'shop floor' or workshop conditions for any significant period of time. The degree of moisture absorption depends on a variety of factors – including the size of the device package, the number of leads and the relative humidity level in the storage environment.

The problem is, that when SMDs are heated up during reflow soldering, this absorbed moisture tends to turn into steam and build up sufficient pressure to cause cracking and other damage inside the package. It can easily damage the chip inside and/or its bonding wires, even if no cracks are visible on the outside of the package.

To minimise the risk of this kind of damage during reflow soldering, chip manufacturers nowadays bake most plastic-package SMDs (especially those in fine-pitch packages) for many hours at 125°C in a very dry and inert atmosphere, to drive out any moisture. Then they are sealed in hermetic packaging (dry packs) and the idea is that they should be left in this packaging until just before they're subjected to reflow soldering.

Now, because this last-minute unpacking isn't practical, even for big manufacturers, and in any case isn't really necessary for some devices, semiconductor industry standards bodies like JEDEC (formerly the Joint Electron Device Engineering Council) have established a system whereby each device is given a rating to show how long it can be safely left out of its hermetic packaging in a typical 30°C/60%RH workshop or factory environment, before reflow soldering. There are eight of these MSL rating levels, ranging from MSL 1 for packages which are deemed impervious to moisture, up to MSL 6 for packages which are very sensitive to moisture and must be reflow soldered within no more than six hours after being removed from their dry packs.

You'll find this MSL rating printed on the dry packs of most SMD devices in plastic packages, and certainly for those in fine-pitch packages (which are almost always rated at MSL 2 or higher). The table below shows the significance of the various MSL levels.

So, what do you do if you want to reflow solder an SMD with an MSL level of 2 or higher, and you know it has been out of its hermetic packaging for longer than its rated safe time? Alternatively, what if it hasn't been out for that long, but has been subjected to very high relative humidity?

The good news is that it can be restored so that it can be safely reflow soldered by baking for about 24 hours at a controlled temperature of between 115°C to 125°C. This can be done in a small fan-driven hot-air oven, provided the device is placed in a small metal box to ensure even heating. The box should also have some small vents to allow the escape of any moisture that is released during the baking.

I made up a small baking oven by converting a fan-type room heater that had been dumped at council clean-up time. The fan motor, fan and heating element were all in perfect working order, as was its thermostat switch.

So, all I had to do was remove these components and convert the heater case into a recirculating-air oven. Then the 'works' were reinstalled and the thermostat tweaked to cycle the oven temperature around 118°C, which produced a rough but quite serviceable DIY baking oven for plastic package SMDs.

JEDEC MOISTURE SENSITIVITY LEVEL (MSL) RATINGS

MSL rating	Safe exposure time at <= 30°C/60%RH before reflow soldering
1	Unlimited (non moisture sensitive)
2	1 year
2a	4 weeks
3	1 week (168 hours)
4	72 hours
5	48 hours
5a	24 hours
6	6 hours (extremely moisture sensitive)

ColdAlert Hypothermia Alarm

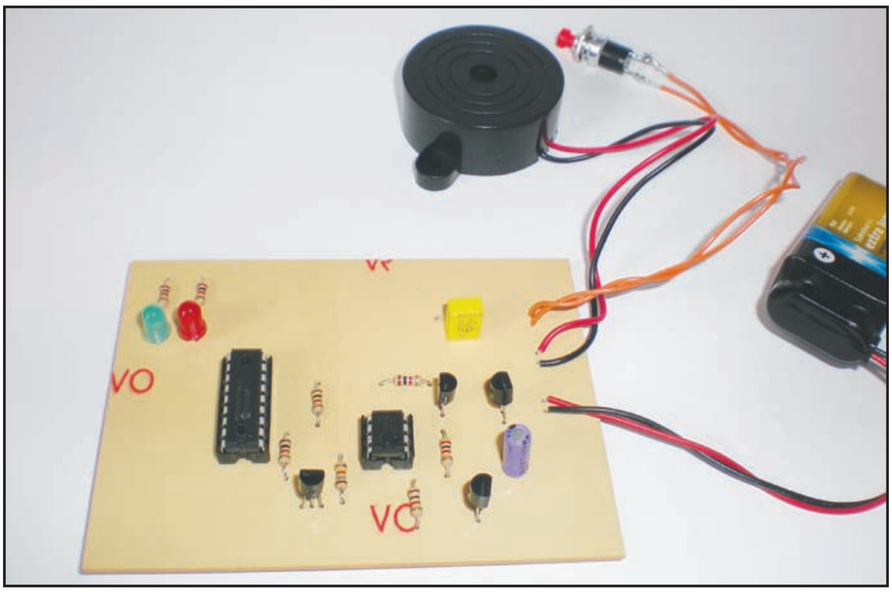
By DAVID CLARK

A low-cost PIC-based alarm to help an elderly or vulnerable person stay warm.

USE the ColdAlert as an excuse to turn up the central heating! Or perhaps, more seriously, use it as a hypothermia alarm to help an elderly or vulnerable person stay warm over the winter months. The ColdAlert hypothermia alarm is a smoke-alarm-style low temperature detector, with a fixed alarm threshold. It will give an audible and visual indication of low temperature, and features a built-in test facility.

For most people, keeping warm is simply a matter of turning up the heating when they 'feel a bit chilly'. Some people, however, cannot tell when they are getting too cold, and these individuals are at risk of hypothermia. This is a condition where the body's core temperature falls below 35°C, and it can be fatal.

Elderly people are particularly vulnerable as there can be a reduced perception of cold accompanied by a lack of shivering due to underlying health conditions, and their room temperature should be kept above 18.3°C. This hypothermia alarm addresses the problem by giving a visual and audible indication of an ambient temperature of below a nominal 19°C.



In use

The device is designed to be used like the familiar smoke alarm found in many homes. Once running, it can be ignored other than by doing a simple check, ideally every day, to ensure that the battery is not discharged, and that the device is working. Similar to a smoke alarm, this is achieved by just a press of a 'Test' button, followed by checking that two light-emitting diodes (LEDs) light and that a buzzer sounds.

In normal operation, a green LED lights up for about a half a second every minute, indicating that all is well and that the ambient temperature is above 19°C. If the temperature falls below this level, a red LED will light and a buzzer sound, both at a frequency of about once per second.

Circuit brief

The full circuit diagram for the ColdAlert Hypothermia Alarm is shown

Parts List – ColdAlert Hypothermia Alarm

1 PC board, code 761, available from the *EPE PCB Service*, size100mm × 75mm
1 case, type and size to choice (optional)
1 pushbutton switch, push-to-make (S1)
1 3V to 15V wire-ended piezo buzzer (WD1)
1 9V battery, with snap-on clip and leads
3 2-way PC-mount terminal blocks (TB1-TB3 optional)
1 8-pin IC socket (IC2)
1 18-pin IC socket (IC4)

Multistrand plastic-covered connecting wire; solder pins; solder

Semiconductors
2 2N3904 *NPN* low-power transistors (Q1, Q2)
1 LM35DZ centigrade temperature sensor (IC1)
1 TS921N CMOS rail-to-rail op amp (IC2)
1 LP2950 +5V low-power voltage regulator (IC3)
1 PIC16F627 preprogrammed microcontroller (IC4)
1 5mm or 3mm red LED (LED1)
1 5mm or 3mm green LED (LED2)

Capacitors
1 2.2µF 100V radial elect. (C1)
1 10nF polyester (C2)

Resistors (0.25W 1% carbon film)
4 1kΩ (R1, R4, R5, R6)
3 2kΩ (R2, R8, R9)
1 10kΩ (R7)
1 18kΩ (R3)

in Fig.1. At the heart of the project is a PIC microcontroller (IC4) and a temperature sensor.

The LM35 temperature sensor (IC1) provides an output of 10mV per °C, and this is multiplied by a factor of ten by an op-amp (IC2) in a non-inverting amplifier configuration to give the microcontroller a reasonable signal to work with. The 100mV/°C signal passes to one input of the microcontroller's comparator module (at pin 2); the other input of the comparator is fed with an internally-generated voltage from the microcontroller's voltage reference module.

Under software control, this reference voltage is set to 18.9°C when there is no alarm condition, and 20.5°C when there is an alarm condition, in order to provide hysteresis and prevent unwanted 'flip-flopping' between alarm and no-alarm when the ambient temperature is crossing the alarm threshold value. This is illustrated in Fig.2.

The microcontroller also takes care of switching on and off the green 'OK' LED, the red 'ALARM' LED, and the buzzer, as appropriate, as well as the timing for these events.

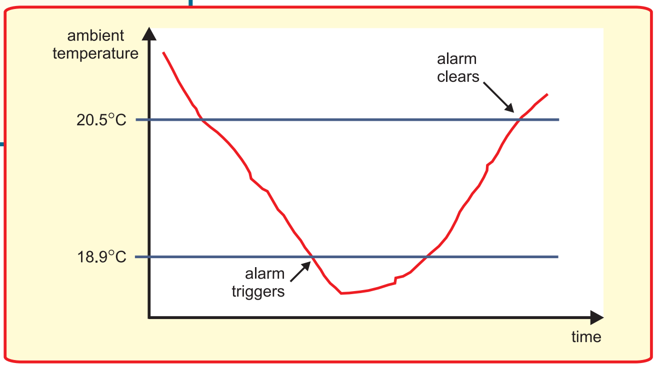


Fig.2. Hysteresis effect at the alarm trigger and alarm clear points

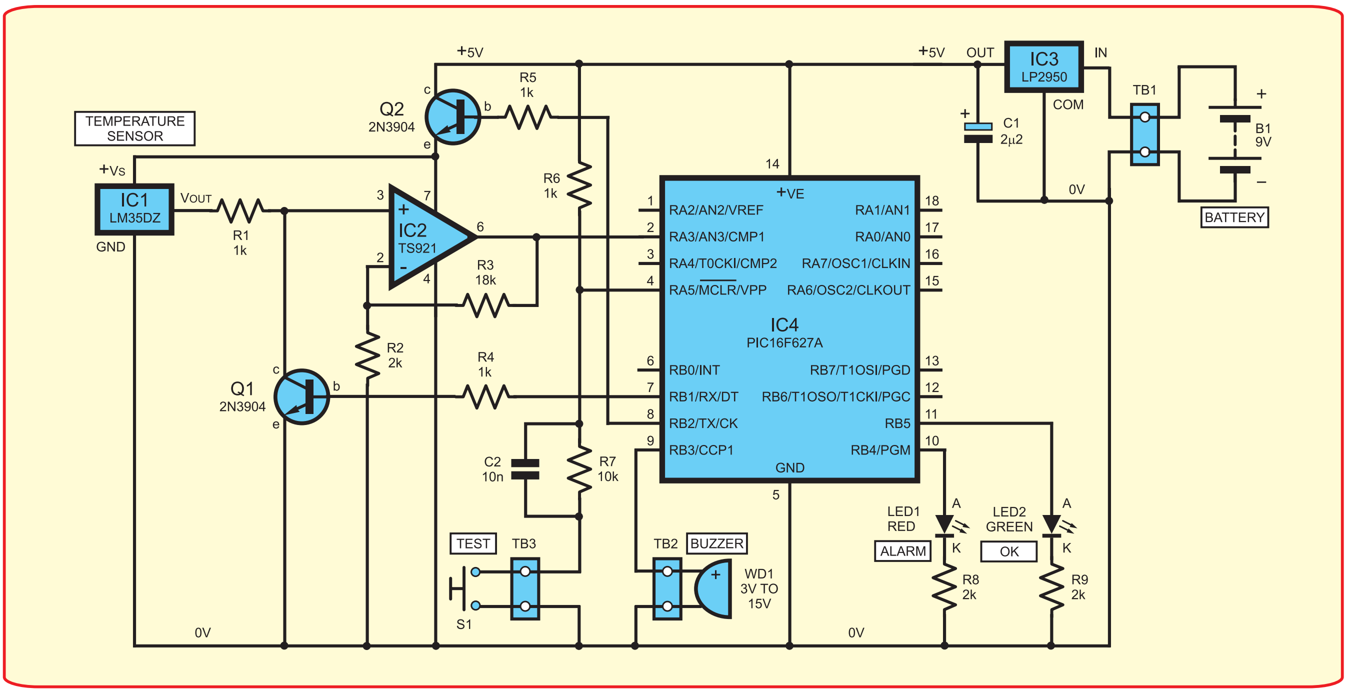


Fig.1. Complete circuit diagram for the ColdAlert Hypothermia Alarm

Alarm test

In order to give confidence that the ColdAlert hypothermia alarm is working properly without having to put it somewhere cold, a built-in alarm test is provided. This works by shorting the output of the temperature sensor to 0V (via a resistor), thus simulating a genuine low ambient temperature and not merely setting a software-generated alarm.

When the 'Test' button is pressed, a two-part check is instigated. The microcontroller is reset via the MCLR (negative logic) pin, and it begins its software routine from the beginning. Components C2 and R7 ensure that pressing the test button causes a reset pulse and does not hold the microcontroller off for as long as the button is held pressed.

After the usual initialisation of microcontroller modules, the next section of the software includes instructions that switch on both LEDs and the buzzer for approximately two seconds – the user must satisfy him- or herself that both LEDs light and that the buzzer sounds. If all is satisfactory, the 'output' part of the alarm is fine. If this is not the case, there is a fault with driving these devices, or an actual device, and the hypothermia alarm must not be used.

Next, again under software control, transistor Q1 is switched on, which generates a simulated low temperature output from the temperature sensor. After two seconds has elapsed, the software tests to see if the internal comparator has generated an alarm; if it has, the 'input' part of the alarm is working, and the software switches Q1 off and proceeds to its main loop, the normal working condition.

If the comparator has not generated an alarm, the software goes into an unending loop and does not proceed to the main loop; both LEDs and the buzzer remain on; in other words, the faulty system cannot be used. The whole cycle can be repeated from the beginning at any time by repressing the 'Test' button.

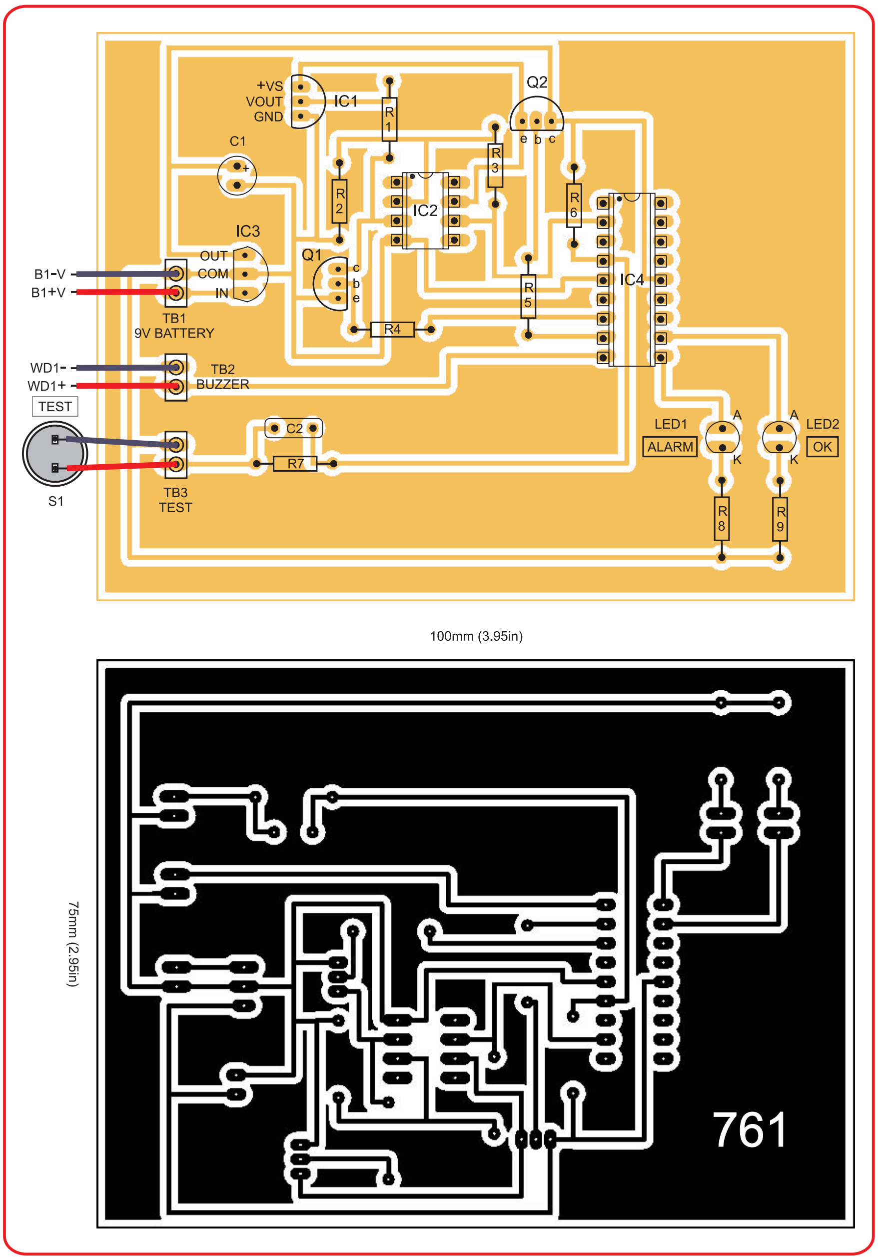


Fig.3. Printed circuit board topside component layout, off-board lead-off details and full-size underside copper master

Normal operation

The main loop takes care of normal operation, which is a temperature check once every minute approximately. If the temperature is higher than the safe threshold, the green LED will light for half a second; if it is lower, the red LED will light and the buzzer will sound, as described earlier.

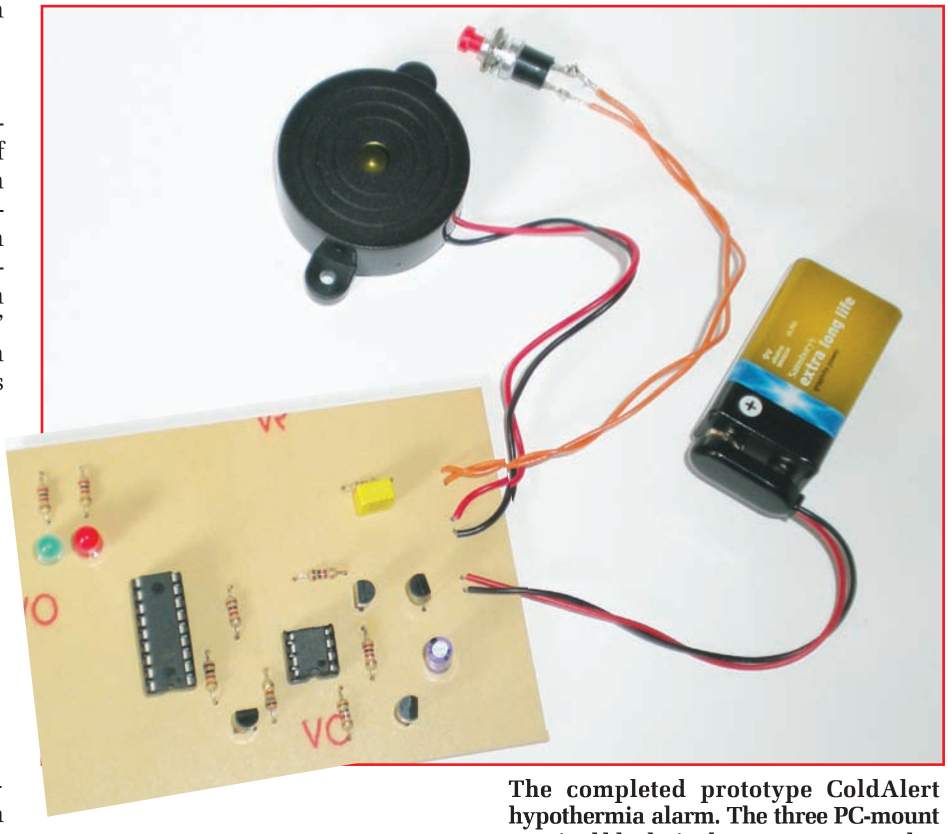
The main loop also takes care of adjusting the voltage reference in order to generate the hysteresis effect already described. As part of normal operation, timing loops are called where necessary, not only for timing the relatively long periods required for operating the LEDs and buzzer, but also shorter 'settling' times for the external temperature sensor and transistors, and internal microprocessor modules.

Micropower

An important aspect of battery-powered equipment that must be permanently switched on is minimising energy consumption. In the ColdAlert hypothermia alarm, this matter is addressed through three factors. First, extensive use is made of the PIC microcontroller's 'sleep' mode for timing delays.

Second, the supply voltage to the temperature sensor and op-amp is switched off (via transistor Q2) between readings. Finally, a micropower LP2950 voltage regulator (IC3)

is used instead of the more common 7805.



The completed prototype ColdAlert hypothermia alarm. The three PC-mount terminal blocks in the component overlay diagram are optional

Battery life

Regarding battery life, an alkaline PP3 battery has a capacity of typically over 500mAh, a lithium version even more. With the hypothermia alarm, current consumption was measured (with a digital multimeter) at around 200μA (when in 'no-alarm' state and with the 'OK' LED off), battery life could be in the order of 1000-plus hours. This might be greatly extended by using, for example, six alkaline or lithium AA batteries (well over 2000mAh).

The use of a low-current LED for the green 'OK' indicator will reduce overall power consumption a bit more, as will increasing the value of resistor R3, but the trade-off is, of course, that the LED will be less visible. There is probably little point in going to great lengths to reduce power consumption in the 'alarm' LED and buzzer, as overall current consumption will be much higher in an alarm condition anyway. Also, hopefully, alarm conditions will be rare.

Software

A comprehensively annotated software listing (.asm) is available from the *Everyday Practical Electronics* Library site, accessed via **www.epemag.com**, along with the hex (.hex) file. A preprogrammed PIC will be available from Magenta Electronics – see their advert in this issue for contact details.

Construction

The ColdAlert hypothermia alarm is built on a small single-sided printed circuit board (PCB), which is available from the *EPE PCB Service*, code 761. The topside (component layout) is shown in Fig.3, together with the full-size copper foil master pattern.

Construction is straightforward, the main consideration being the correct orientation of the integrated circuits (ICs), transistors and LEDs, and the correct polarity of the connections to the battery and buzzer.

The op-amp (IC2) and PIC (IC4) are best mounted in IC holders, particularly the PIC, in case it needs reprogramming for any reason, or if you want to modify the code. In any event, the semiconductors should be fitted last to minimise the possibility of electrostatic damage.

In case?

There are some problems that need to be considered if you want to fit this project in an enclosure. Most importantly, there needs to be a free flow of air around the temperature sensor (IC1) for it to react as quickly as possible to temperature changes.

Also, the PCB connections to the sensor and the LEDs will need to be extended via wire leads, which will increase the possibility of short circuits or broken connections, naturally making the alarm ineffective. However, it looks neater!

Finally

There are well over 100 deaths a year in the United Kingdom due to hypothermia in the elderly. Hopefully, the ColdAlert will help prevent this tragic outcome of not being warm enough at home. However, please remember – this is a hobby project and not a medical device. Use it as an AID to, NOT as a substitute for, proper medical and social supervision of a vulnerable person.

Like a smoke alarm, the hypothermia alarm is a preventative device, and, like a smoke alarm, it will be doing its best job if its alarm never sounds – but don't forget to test the alarm at regular intervals.

Source of hypothermia information – *Merck Manual of Geriatrics* website: **www.merck.com/mkgr/mmg/sec8/ch67/ch67b.jsp)**.

EPE EXCLUSIVE

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PIC24FJ64GB004	32-64	28-44	OTG, Dual Role, Embedded Host, Device	20	220	520

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Recycle It!

BY JULIAN EDGAR

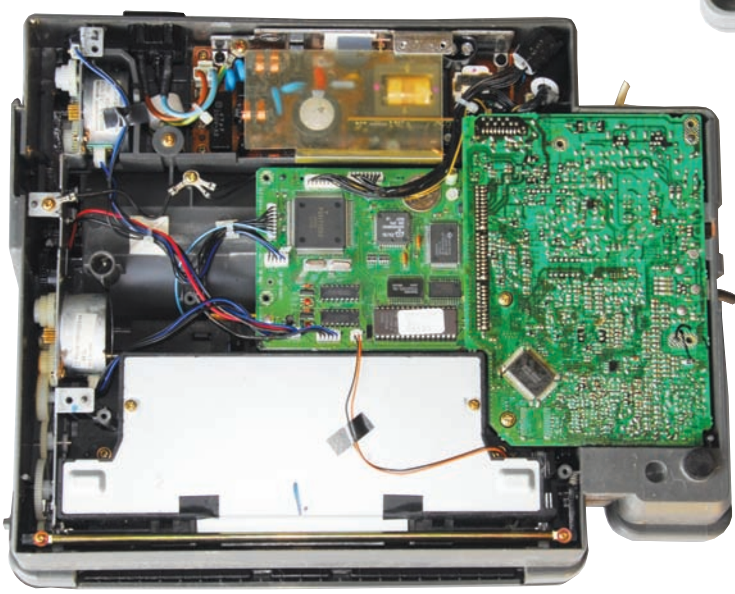
Fax Machines and Hair Trimmers

This month, fax machines and hair trimmers get the 'short-back-and sides' treatment

ALONG with the original Luddites, thermal fax machines are victims of the technological revolution. But you won't find fax machines destroying cotton and wool mills – instead you'll find them forlornly sitting among municipal refuse at the rubbish tip, or for sale for nearly nothing at garage sales, or put out for kerbside rubbish collection. You might even have one yourself, tucked into a back cupboard, never to be used again.

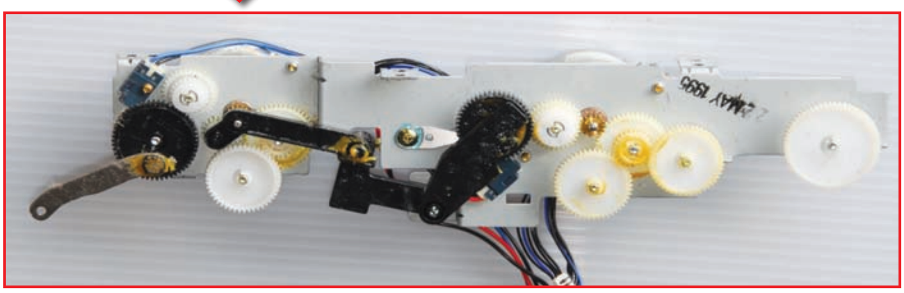
But fax machines are definitely worth pulling apart for the components you'll find inside – often, as is the case with paper-handling consumer goods (think also printers and photocopiers), for the mechanical parts as much as for the electronic bits.

This Panasonic KX-F2500 was found at the local tip. The person who had discarded it had kept the telephone handset and the IEC power cord – but that's OK, there are still plenty of good bits left inside. As with most of these sorts of items, the heavier the machine is, the more likely it is to have better quality parts inside. This fax machine was quite weighty.



A few screws later and the insides were revealed. The drive assembly, comprising two stepper motors, gear-trains and one-way clutches, can be seen at left. At the top is a switch-mode power supply and lots of screws and wires can also be glimpsed. This looks like it will be good!

The removed dual stepper motor gear-train. Very usefully, the whole assembly comes out as a single piece. This means that whenever a stepper motor needs to be geared down (think robots or model railways, for example) the reduction gear-train can be used without modification. It also means that where the stepper motor needs to be driven at high speed (for example, when making a hand-cranked alternator) this, too, can be easily achieved.



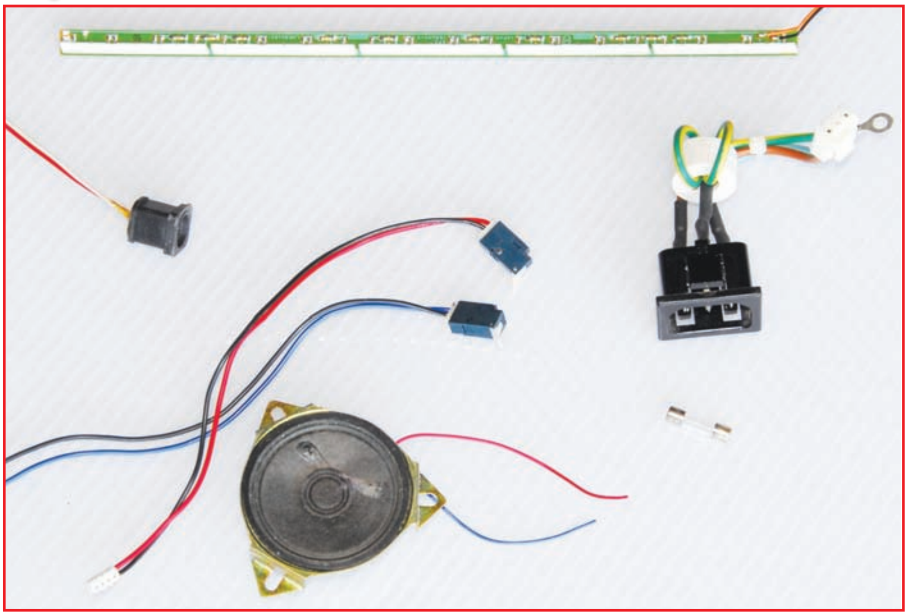
Inside this fax machine – and most of a similar design – you'll find plenty of steel shafts with rubber rollers mounted on them. The rollers are easily removed from the shaft by setting a bench vice so that its jaws are just a little further apart than the diameter of the shaft. The shaft can then be placed in the vice vertically, the rubber roller bearing against the top of the jaws. A hammer and punch can then be used to push the shaft through the roller.

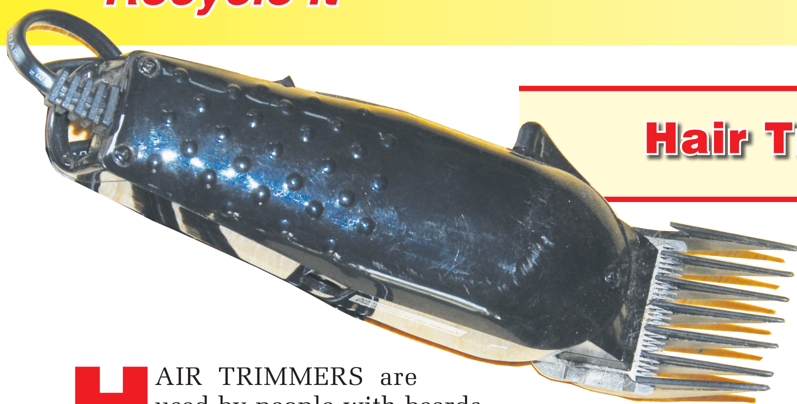
Shown here are three rubber rollers - excellent as anti-vibration mounts, for making grommets or as an additional handle grip on small screwdrivers. Also pictured are six steel shafts (uses? think axles, spacers, hooks...), a variety of springs and some self-tapping and machine thread screws. Incidentally, the other day I was in a hardware store and I caught sight of their new range of springs. At the prices they're charging for a single spring, I must have accumulated about £100 of salvaged springs!

Here's another goody. It's the lens – and it's sharp and has a useful magnification. In fact, it's perfect for hand-lens use, like reading the values of glass fuses, checking resistor codes and the like. Because I already have enough of them, in this case I didn't bother salvaging the rectangular glass sheet over the LED light or the front-faced mirrors that are also part of the optical system.

I chose not to salvage the switch-mode power supply, miniature pushbuttons or the handful of PCB-mounted LEDs. Instead, I rapidly obtained a microphone, small speaker, two microswitches with levers, a female IEC power cable socket and a fuse.

So what's that long thing up the top? It's one of the beauties out of a fax machine – the LED bar that illuminates the paper when a printout is being scanned. This one comprises 30 surface mount green LEDs, the 'bar' illuminating superbly on 12V. It's perfect for concealed front panel lighting on equipment that needs to be used at night (just mount the light-bar behind a bezel); for decorating a clear PC case; or even for sophisticated glovebox lighting in your car!



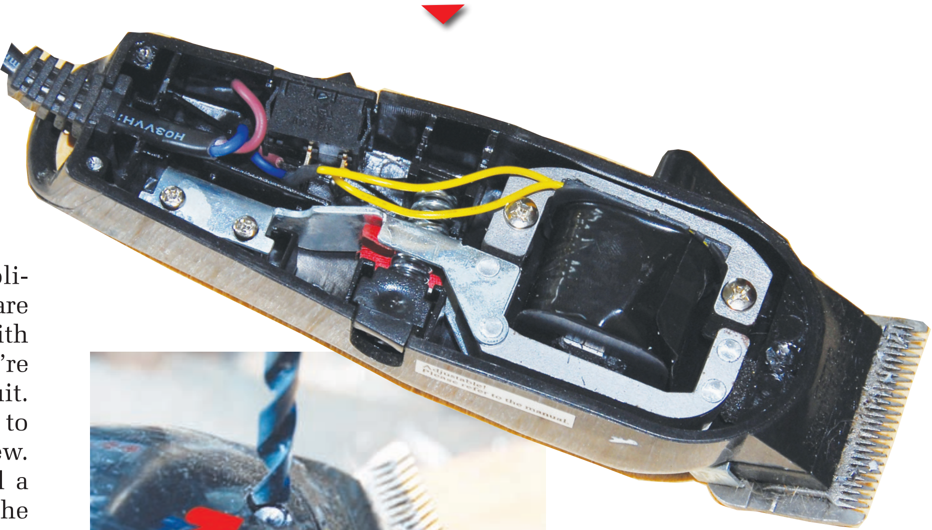


Hair Trimmers – short cuts

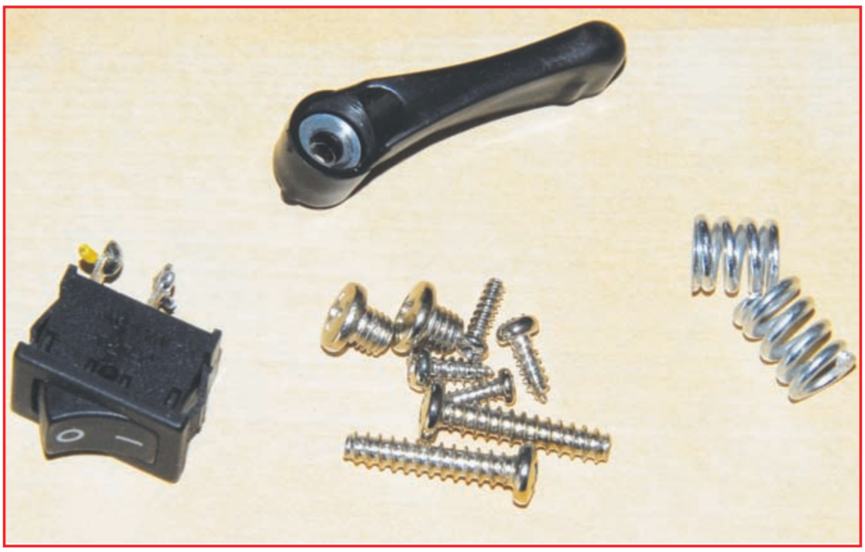
HAIR TRIMMERS are used by people with beards – and often by people with dogs! Some people also cut their own hair using a trimmer. Hair trimmers are now very cheap, and so when they clog up or their blades lose their sharpness, they're simply thrown away. But for a small, cheap item, there's a surprising number of parts inside that can be re-used.

As with many other small appliances, these days hair trimmers are often put together with screws with odd-shaped heads – heads that you're not likely to have a screwdriver to suit. If that's the case, the easiest way in is to simply drill out the head of the screw. Three screws were drilled-out and a few moments later, the cover of the trimmer could be pulled off.

Here's the view inside. An electromagnet, connected directly to mains power, pulls in an arm that is connected to the moving section of the blades. As the current alternates, so the blades move back and forth. Adjustable springs set the spacing between the solenoid and the moving plate. With the adjustment correct, the plate and solenoid do not come in contact with one another.



A few moments later and you have available a 10 amp mains power switch, some screws (including two made from stainless steel), a lever, the perfect size to fit to a potentiometer, and two springs.



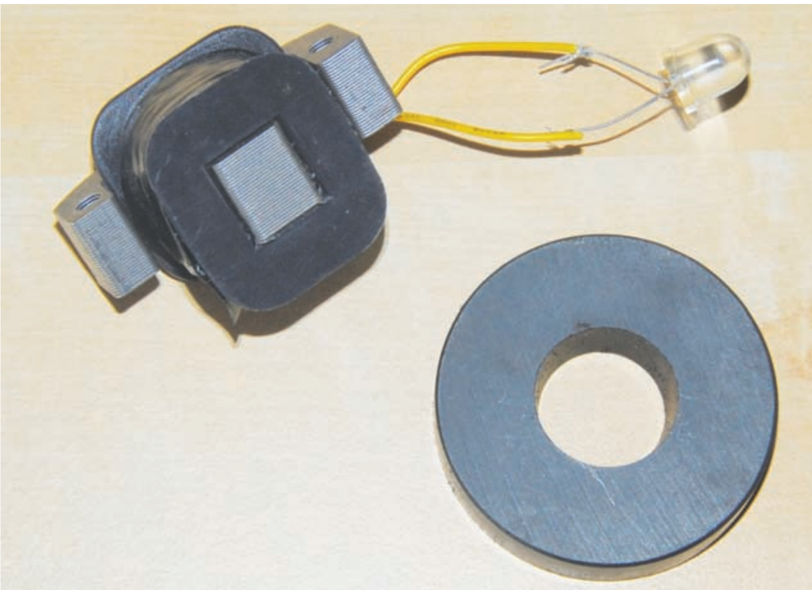
Rat It Before You Chuck It!

Whenever you throw away an old TV (or VCR or washing machine or dishwasher or printer) do you always think that surely there must be some good salvageable components inside? Well, this column is for you! (And it's also for people without a lot of dough.) Each month we'll use bits and pieces sourced from discards, sometimes in mini-projects and other times as an ideas smorgasbord.

And you can contribute as well. If you have a use for specific parts which can easily be salvaged from goods commonly being thrown away, we'd love to hear from you. Perhaps you use the pressure switch from a washing machine to control a pump. Or maybe you have a use for the high-quality bearings from VCR heads. Or perhaps you've found how the guts of a cassette player can be easily turned into a metal detector. (Well, we made the last one up, but you get the idea . . .)

So, if you have some practical ideas, do write in and tell us!

An unexpectedly useful part is the larger section of the comb. It's sharp, made from stainless steel and is ideal as a scraper. I use mine to roughen surfaces before gluing them together – and I've never used a better tool for this job!



Finally, there's the mains-power solenoid. I found one of the simplest, yet most intriguing uses is to show children the connection between magnetism and electricity. With the solenoid wired straight to a 10mm LED, a wave of the circular magnet (salvaged from a microwave oven) lights the LED up brilliantly. Instead of the LED you can use a VU or power meter salvaged from a cassette deck or amplifier.

CIRCUIT SURGERY

REGULAR CLINIC

BY IAN BELL

Regulators – a hot topic

Brian Heath emailed the following question:

I wonder if you could help me with a problem I have with power supplies. I am an amateur astronomer at the Sherwood Observatory with an interest in Radio Astronomy and have just completed my RSGB intermediate exam. I have built some equipment using my rather basic knowledge in electronics, and for my power supply have built my own with the standard 78XX series regulator and another to a Velleman design sourced through EPE.

The problem I find is that a lot of heat is generated by both designs, and I am looking for 12V DC and 6V DC circuits that run much cooler without huge heatsinks. I have searched several sources, but they all use the same technology.

The power is for several pieces of equipment, from telescope drives and computer drives for the equipment, to small web cams and video cameras. The current demands are up to 2A. We find that we require several controllers and would like to mount them in one box to suit the particular application, rather than have several supplies through individual transformers.

Your assistance in this would be appreciated, as astronomy, while a minority interest, is growing and we are now using more electronic controls, but available designs are lacking. Hoping you can rescue me and my Astronomical Society from this small but important set back.

Brian also provided some further information about the power source used:

What I have done in the past is to feed the controller from a 15V to 20V mains transformed AC supply. I then use a bridge rectifier of the correct rating to give me a DC supply. It is from there I am lost. If the circuit has a rectified section then I would use this. We always run cables to equipment in voltages below 24V AC.

A simplified block diagram of a power supply, based on a linear regulator such as the 78XX series devices that Brian mentions, is shown in Fig.1. A typical circuit for using the regulator is shown in Fig.2.

The 78XX series regulators are generic devices, available from a number of semiconductor manufacturers (for example Fairchild Semiconductor, see **www.fairchildsemi.com**), and have been around for a long time. National Semiconductor (**www.national.com**) describes the LM78XX devices as obsolete, as they have replaced them with the LM340 series; although the datasheet is still titled 'LM340/LM78XX Series'. The XX in '78XX Series' indicates the regulated output voltage, values of 5V, 6V, 8V, 9V, 12V, 15V, 18V and 24V are available.

In Fig.2, capacitor C_I is required if the regulator is located a significant distance from the power supply smoothing capacitors, or if the output load capacitance is large. A tantalum, mylar or other capacitor with low impedance at high frequencies should be used. It should have short leads and be located as close to the regulator as possible. We will discuss C_O later in the article.

The 78XX series regulators are available in a variety of packages, so you should always check the pinout for the package you have on the manufacturer's datasheet before using it. Choice of package also influences maximum power dissipation and heatsink requirements.

Power dissipation

The fundamental cause of the power dissipation problem that concerns Brian is the voltage drop across the regulator. Fig.1 shows the current and voltages in and out of the regulator. The voltage drop across the regulator is $V_{in} - V_{out}$ and the current through the regulator (to the load) is I_{out}. The power dissipated by the regulator in delivering the output current is $I_{out} \times (V_{in} - V_{out})$.

The regulator will also require some internal current to ground, labelled I_{gnd} on Fig.1. The ground current will result in additional power dissipation equal to $I_{gnd} \times V_{in}$. So the total power dissipation is

$$P = I_{out} \times (V_{in} - V_{out}) + I_{gnd} \times V_{in}$$

In most cases, the power due to the drop across the regulator will dominate the power dissipation, so we may not have to calculate $I_{gnd} \times V_{in}$ to get a good idea of the dissipation.

Using this simplification, if Brian uses a 20V input to a 12V, 1A regulator the power dissipation will be at least (20-12) × 1, which is 8W. This is around the maximum

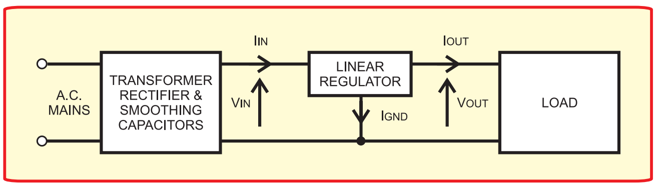


Fig.1. Simplified block schematic diagram for a power supply using a linear regulator

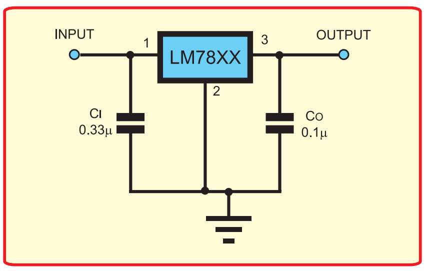


Fig.2. Typical circuit for an LM78XX series regulator

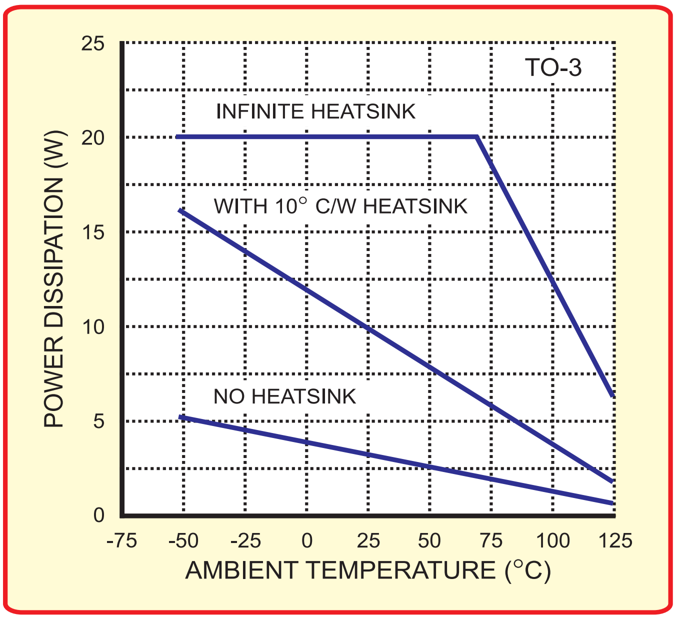


Fig.3. Maximum power dissipation characteristics for LM340/LM78XX in T0-3 package. (National Semiconductor datasheet **www.national.com**)

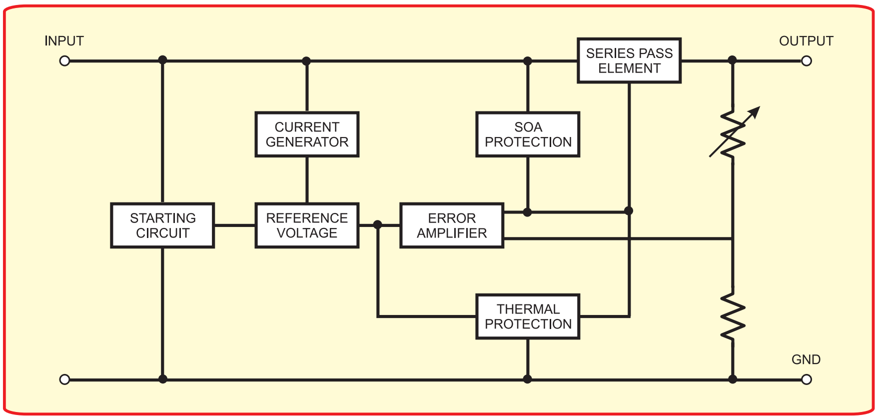


*Fig.4. Block diagram for LM78XX series regulators. Based on Fairchild Semiconductor datasheet (**www.fairchildsemi.com**)*

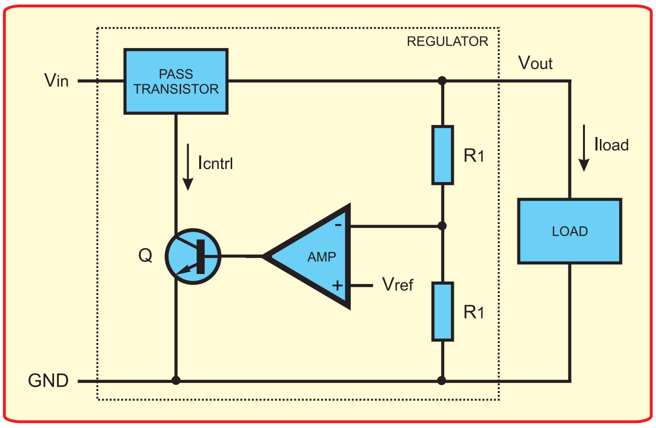


Fig.5. Simplified internal circuitry for the linear regulator

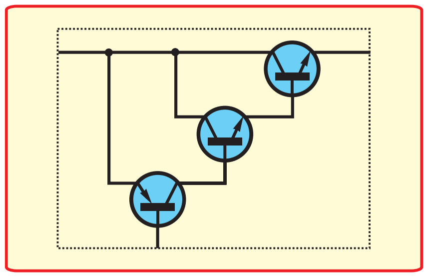


Fig.6. Typical 'pass transistor' for a standard regulator

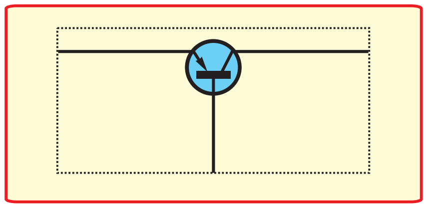


Fig.7. Typical 'pass transistor' for a low dropout (LDO) regulator

power dissipation of a 78XX regulator in a TO-3 package when using a 10°C/W heatsink at 25°C ambient temperature (from National Semiconductor LM340/LM78XX datasheet, see Fig.3). So it is not surprising that the circuits run hot as Brian describes.

The simplest solution is to reduce the regulator input voltage, but in doing so we have to be aware of the minimum input-to-output voltage difference required by the regulator for it to operate, this is known as the dropout voltage. The datasheet for the regulator chip again provides the figures we need; the dropout voltage is 2V for the LM340/LM78XX at I_{out} = 1A.

However, this is not the whole story, with the input-to-output voltage at its absolute minimum, the regulator's performance may be compromised – it may not regulate as well as it should. The datasheet also quotes the minimum input voltage required to maintain regulation, this is 14.6V for a 12V regulator at I_{out} = 1A and an ambient temperature of 25°C. Using this minimum voltage difference we get a dissipation of (14.6-12) × 1, which is 2.6W.

According to the datasheet graph for the TO-3 package, this is close to the maximum dissipation without a heatsink at 25°C ambient temperature. It may be too close for comfort though if the power supply is not in a well ventilated case or if it is used in a warm environment. However, the heatsink requirements are certainly less than with a 20V input.

In general, the 78XX series devices tend to need heatsinks when supplying their maximum rated output current of 1A. If they do overheat they should not be destroyed because they include thermal shutdown; Fairchild describe them as 'essentially indestructible' in the datasheet.

Safe operating area

An internal block diagram for the LM78XX series regulators is shown in Fig.4. Protection is provided by the 'safe operating area' and 'thermal protection blocks'. If the regulator is overloaded or its output is shorted, the safe operating area circuit will take it into constant-current mode (in which the output voltage is reduced to maintain a constant load current, hence limiting dissipation).

Even with this protection, the regulator may overheat; what happens will depend on the ambient temperature and the size and quality of regulator's heatsink (if there is one). If the regulator reaches its maximum temperature, the thermal protection activates, reducing the load current. Reducing the load current will reduce the heat dissipated by the regulator, so the circuit will reach a point of balance between the dissipation tending to heat it up and the protection circuit winding down the supplied current to reduce the power.

Before returning to the issue of input-to-output voltage drop, it is useful to look at another simplified representation of the regulator's internal circuitry, as shown in Fig.5. The regulator controls the current supplied to the load in such a way as to keep the supply voltage (regulator output voltage, V_{out}) constant. It uses a potential divider to produce a fixed fraction of the regulated supply voltage, which is compared to a fixed reference voltage.

If the output voltage decreases the amplifier output will increase because the potential divider is connected to the inverting input. The increased output voltage will increase the control current to the pass transistor and hence the current to the load, which will tend to increase the output voltage and offset the tendency for decreasing output voltage caused by the increasing load. This negative feedback loop will keep the potential divider voltage equal to the reference voltage and hence keep the output voltage fixed as the load varies.

The 'pass transistor' circuit used inside a standard regulator is shown in Fig.6. This circuit actually uses multiple transistors and requires a minimum of 2 V_{BE} and one $V_{CE.SAT}$ voltage drop across it, accounting for the typical dropout voltage in the range 1.5V to 2.5V for this type of regulator.

The transistor arrangement shown in Fig.6 is used because its characteristics are helpful in achieving stability of the previously mentioned feedback control loop, which is at the heart of regulator operation. Any feedback control system has the potential of becoming unstable if the conditions under which it operates shift too far from the ideal. In a regulator circuit, such instability takes the form of oscillation of the output voltage.

The standard linear regulator, with the pass circuit shown in Fig.6, is very stable under a wide range of conditions and thus is very easy to use. The price paid for this is the large minimum input to output voltage (dropout voltage) and high power dissipation.

Low dropout

It is possible to use a different pass circuit, which requires a smaller voltage across it, and therefore to have a regulator with a much lower dropout voltage, and thus potentially much higher efficiency. Such circuits are called 'low dropout' (LDO) regulators and typically use a single transistor as the pass element (see Fig.7). Their downside is that the stability of the control loop is much more sensitive to the external load impedance than with a standard linear regulator. LDO regulators often have dropout voltages of less than 500mV, and low as 20mV for low current loads.

In Fig.2, the regulator is shown with an output capacitor C_O. This capacitor is not essential for a standard linear regulator, but does improve the transient response of the circuit.

The situation is different for LDO regulators – they do require an output capacitor, and the capacitor characteristics are often critical for stable circuit operation. For LDO circuits, it is not just the capacitance of C_O which is important, but also its equivalent series resistance (ESR). The ESR of C_O affects the overall impedance characteristics seen by the regulator output and hence the stability of the circuit.

LM2940

The LM2940 from National Semiconductor is an LDO regulator that is able to provide up to 1A of output current, like the 78XX series devices. Output voltages of 5V, 8V, 9V, 10V, 12V, and 15V are available. The dropout voltage is much smaller than the 78XX series, being typically 0.5V, and no more than 1V over the whole operating temperature range of the device.

The LM2940 is aimed at vehicular applications and has enhanced protection/shut-down features; for example, against protected reverse input voltage. Standard regulator protection features, such as short circuit and thermal overload protection, which we discussed above, are also provided.

The basic circuit for the LM2940 is the same as Fig.2, but the capacitor requirements are different. Like the 78XX series, the input capacitor C_I is required if the regulator is not very close to the power supply filter. A value of 0.47µF is recommended. Unlike the 78XX series, C_O is required and must be at least 22µF to maintain stability and must be located close to the regulator. Its value may be larger than 22µF and this will help with maintaining the output voltage during load demand transients.

The equivalent series resistance (ESR) of C_O is critical and must be maintained over the operating temperature range. The ESR value must be between about 0.1Ω and 1Ω (both too low and too high can cause instability), but the datasheet should be consulted for full details.

The requirement for a 22µF capacitor would seem to indicate an aluminium electrolytic part, but these are not recommended in this circuit because their ESR is not stable with temperature. National Semiconductor recommends using a solid tantalum capacitor for C_O, but this may be expensive. The datasheet also indicates that it may be possible to use a (lower value) tantalum and aluminium electrolytic in parallel to reduce the cost.

Semiconductor man-ufacturers have worked to developed LDOs with less stringent requirements on the output capacitors. For example, the LP38690 1A low dropout CMOS linear regulators are stable with ceramic capacitors. However, not all types of ceramic capacitor are suitable for regulators quoted as being stable with ceramic capacitors. This is due to the differing properties of different ceramic dielectrics. For example, some have capacitance which is quite voltage dependent. The LP38690, however, may not be suitable for Brian, as these regulators are only available in voltages up to 5V, and are aimed at digital systems such as notebook computers.

High output current

Brian's requirements for output currents up to 2A go beyond the capabilities of the 78XX series and the LM2940 LDO regulator we have just discussed. Higher current devices are available though, for example the LT1083/LT1084/LT1085 7.5A, 5A, and 3A LDO regulators from Linear Technology (**www.linear.com**). These are all high efficiency regulators with a 1V dropout voltage and are available in both fixed and adjustable formats.

The available fixed voltages are 3.3V, 3.6V, 5V and 12V, which does not include the 6V required by Brian, so an adjustable regulator would be needed for this. The circuit for the LT1083 series adjustable regulators is shown in Fig.8, together with the formula for setting the output voltage. Another possibility from Linear Technology is the LT1086 Series 1.5A LDO regulators, which also include a 12V fixed output voltage version and an adjustable device.

As expected with an LDO regulator, the LT1083 and LT1086 family devices require an output capacitor for stability. The minimum requirement is a 10µF solid tantalum cap-acitor. For all operating conditions, use of a 150µF aluminium electrolytic or a 22µF solid tantalum on the output will ensure stability, but often smaller values than this can be used. The datasheet provides all the details needed when choosing a suitable capacitor.

Like the other regulators we have discussed, an input capacitor is required for the LT1083 and LT1086 series devices if the regulator is not close (two inches is quoted on the datasheet) to the smoothing/filter capacitors. A 10µF solid tantalum capacitor is recommended.

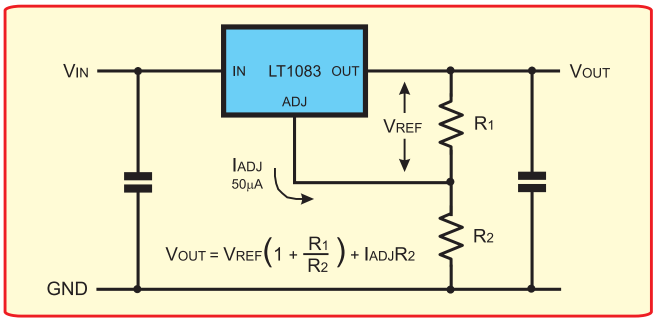


Fig.8. Basic circuit for the LT1083 family of adjustable regulators form Linear Technology (www.linear.com)

Use of LDO regulators should help Brian with his excessive power dissipation, as long as the input voltage to the regulator is kept at a reasonably low value. Ideally, it should be just above the voltage at which the regulator works correctly, but this may be difficult to achieve if the load current varies a lot and causes the voltage from the circuitry before the regulator to vary.

More sophistic-ated circuits can be built to overcome this using another regulator to pre-regulate the input to the LDO regulator. The pre-regulator will typically be a very high efficiency, switch-mode regulator. The LT1083/LT1086 datasheets provide example schematics of pre-regulated LDO regulators.

Datasheets

www.national.com/ds/LM/LM340.pdf
www.national.com/ds/LM/LM2940.pdf
www.fairchildsemi.com/ds/LM%2FLM7812.pdf
cds.linear.com/docs/Datasheet/1083ffd.pdf
cds.linear.com/docs/Datasheet/108345fg.pdf
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Practically Speaking

Robert Penfold looks at the Techniques of Actually Doing it!

THE hobby of electronics is not really comparable to any other pastime. It contains elements of other hobbies, such as computing and metalworking, but it also requires a unique set of skills, and perhaps a wider range of skills than practically any other hobby.

Articles in this series normally concentrate on one specific area of electronic project construction, but this month an overview of project building will be provided. For complete beginners, this should give a good idea of exactly what is involved in building an electronic gadget, the tools required, and whether it is something they would like to try.

The right stuff

The first task facing the constructor is to obtain all the parts required for the chosen project. The days of going to your local radio and electronic component shop for *all* the parts are now long gone. You might be lucky enough to live reasonably close to a large electronics store that can supply all or most of the components for a particular project, but these days the majority of components are purchased by mail order or online.

Some components will be advertised in the pages of *EPE*, but most will have to be sought in the catalogues of *EPE* advertisers, and possibly in the huge online component catalogues of the major electronic component suppliers. The large companies such as Farnell and RS Components are primarily suppliers to commercial customers, but they will supply to private individuals via their online ordering systems.

It is a good idea to browse some printed or online component catalogues, which usually contain photographs of components and a great deal of useful information. This will help you to familiarise yourself with electronic components and reduce the risk of buying the wrong parts.

The more specialised components, including many integrated circuits (ICs) and other semiconductors, tend to come and go relatively quickly these days. It is, therefore, important to make sure that all the components for a project are still available before starting to buy any of them. This is especially important when building a project from an article that was published more than a few years ago.

Nuts and bolts

Having assembled all the parts, it is time to start building, and it is probably best to deal with the mechanical side of construction first. This usually involves nothing more than drilling and cutting some holes in the case. Things such as switches and sockets are mounted in these holes, and there might also be holes to permit the circuit board to be fixed to the case.

With this method, the circuit board is hard-wired to the controls, sockets and switches in the final stages of construction. An alternative approach is to have the controls and sockets fitted along one edge of the circuit board, and fixing these in the case then provides the mounting for the circuit board as well.

Preparing the case is much the same either way. Many of the tools required can be found in the average do-it-yourself tool kit. However, it will almost certainly be necessary to buy some additional tools, but it is better to add them as and when they are required, rather than buying lots of likely looking tools, some of which may never be needed.

It is a good idea to start with a project that is fairly straightforward as far as the mechanical aspects of construction are concerned. There will be plenty of new things to learn when dealing with the electronics, and it is probably best to concentrate on mastering these and to avoid getting distracted by any difficult or very time consuming facets of the mechanical side of construction.

If they are not already present in your toolkit, it will certainly be necessary to obtain some small electricians' screwdrivers. Wire cutters and insulation strippers are also essential. These can be obtained as separate tools, but initially an inexpensive combined wire cutter and stripper tool should suffice. Do not improvise using tools such as scissors and penknives. Doing so is likely to damage the tools, the wires, and yourself!

Holing out

Drilling holes in metal or plastic cases requires ordinary HSS twist drill bits. Electronic project construction often involves working on a small scale using relatively soft materials, such as plastics and aluminium. A large power drill is usable, but should preferably be fitted in a good quality stand. Something like a small cordless drill or even a hand drill is often better suited to the task. A set of miniature files are useful for 'fine tuning' any holes that are not quite right at the first attempt, and for making non-circular cut-outs such as the rectangular mounting holes required by some panel lights and switches.

Last, and by no means least, you will need somewhere to carry out the drilling and cutting. It does not matter too much if you do not have the luxury of a room dedicated to hobby pursuits. I would guess that by now there must be many millions of electronic projects that have been built on kitchen tables, or other parts of the house annexed from their normal functions.

Due care must be taken to avoid damaging tables or other work surfaces, and it will probably be necessary to improvise a temporary worktop from a piece of MDF or chipboard. Always make sure that the work area is properly cleared of any sawdust, swarf, or other scrap, once the work has been completed.

Highly charged

With work on the case completed it is time to move on to the circuit board. It is tempting to start with a fairly large and impressive project, but something fairly simple and straightforward is a more practical choice for a first project. The larger the project, the greater the chances of a mistake being made and the finished unit failing to work. The chances of successfully completing a project are very high if something fairly simple is chosen, and construction is tackled in a methodical and careful manner, with nothing being rushed.

An unavoidable complication of modern electronic project building is that many semiconductors are vulnerable to being zapped by high 'static' voltages. These voltages are a normal part of our environments, and you could well have them in your immediate vicinity while reading this piece. These days, most integrated circuits seem to be vulnerable to static charges, as are some other semiconductor components. If in doubt, always operate on the basis that semiconductors require antistatic precautions. Using antistatic precautions was covered in the *EPE* March '10 issue, and it will not be considered in detail again here.

One important point is to resist the temptation to remove vulnerable components from their protective packaging to have a closer look at them. Any unnecessary handling of static-sensitive components should be avoided. It is advisable to obtain one or two items of antistatic equipment at an early stage, and right away if your first project uses any expensive semiconductors. A conductive wristband and earthing lead can be obtained quite cheaply, and will largely eliminate the risk of accidentally zapping any sensitive components.

On the board

Most or all of the electronic components are fitted onto a circuit board of some kind. This will usually be in the form of a dedicated printed circuit board that is designed specifically for one circuit. The

board is made from an insulating material such as fibreglass, and it has holes to take the pins and leads of the components.

In its most simple form there are copper pads and tracks on one side of the board. The components are fitted on the other side of the board, which is generally considered to be the top side, the leads are trimmed to length, and then they are soldered to the copper pads on the underside of the board. The copper tracks carry the interconnections between the components, forming the correct circuit.

There are variations on this basic scheme of things, and some boards are double-sided (see Fig.1). These usually have components fitted on only one side, but there are tracks on both sides of the board. There are additional holes that are used to carry connections through the board, and this enables connections to weave across the board from one side to the other, crossing over other tracks on the way. Assuming a ready-made board is used, for the constructor it makes little difference whether the board is a single or double-sided type.

proprietary product that is designed to accommodate practically any circuit. The board has numerous small holes on a 2.54mm × 2.54mm matrix. Copper strips on the underside of the board run along the rows of holes (see Fig.2.).

Stripboard is used much like an ordinary printed circuit board, with the components fitted on the plain side of the board and soldered to the copper strips on the underside. It is invariably necessary to make cuts in the copper strips at appropriate places, so that some strips can carry more than one set of interconnections. Most circuits built using stripboard also require numerous wires on the top side of the board to link sections of copper strip. These link wires are sometimes required with custom single-sided boards as well.

A custom printed circuit board is generally easier to use than stripboard. With a custom board there is a hole for each component lead or pin and no 'spares'. The situation is very different with stripboard, where the vast majority of the holes are normally left unused, and getting a component in the wrong place is all too easy.

There is insufficient space here for a detailed description of good soldering technique, but an excellent soldering guide is available on the *EPE* website, and soldering irons sometimes complete with detailed instructions.

A couple of points to keep in mind are that the surfaces to be joined *must* be clean, and the iron should be applied to the joint first, and then the solder should be fed into it. Do not make the classic mistake of melting some solder on the iron and then applying it to the joint. It is a good idea to obtain some stripboard and a few inexpensive components, such as resistors, so that you can practice and become proficient at soldering before moving on to the genuine article.

Finishing off

With the completed circuit board fitted in its case, it is then just a matter of adding any interwiring needed to complete the project. This wiring is perhaps less straightforward than fitting the components to a circuit board, but where appropriate, there should be a wiring diagram that clearly illustrates

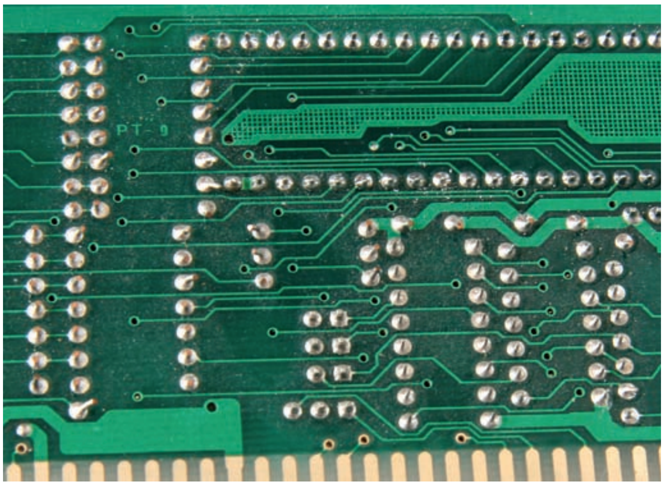


Fig.1. The underside of a double-sided printed circuit board (PCB). The empty holes have metal plating that carries connections through the board. Some double-sided boards require tiny pins and soldered connections on both sides of the board to provide these connections

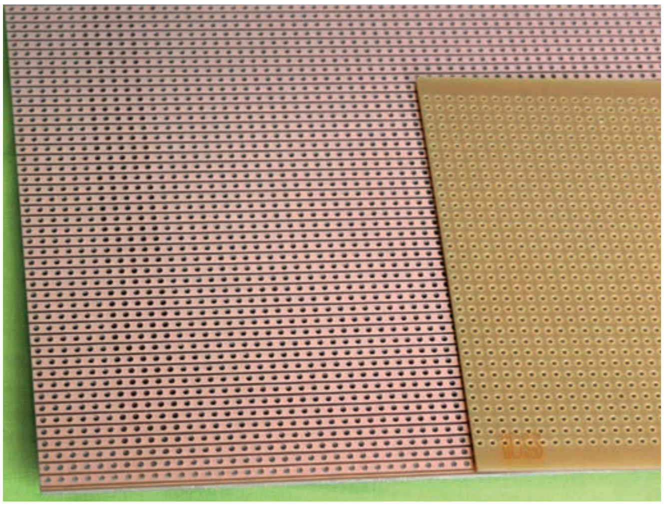


Fig.2. Stripboard has a matrix of holes with copper strips on one side of the board. It is usually necessary to make breaks in some of the strips, either using a special tool, or a drill bit of about 5mm in diameter, which does the job quite well

Another variation certainly does make a big difference when it comes to actually building the board, and this is where surface-mount devices (SMDs) are used. Surface-mount components are generally much smaller than their conventional counterparts, which means that most of them are minute. They have no leadout wires, but instead have metal pads that are soldered to 'holeless' copper pads on the board. The board can be single or double-sided.

A further variation is to have a conventional board that also takes a few surface-mount components. This can be necessary if some of the components used in the project are only available in surface-mount versions. Using surface-mount components is, to say the least, a bit tricky, and it is probably best to avoid this type of construction until some experience has been gained building conventional circuit boards.

Stripboard

Stripboard is yet another type of printed circuit board. It is basically just a form of single-sided circuit board, but it is a

Ordinary printed circuit boards are by no means immune to accidental short circuits between pads due to minute blobs of excess solder, but it is something that seems to be a much more significant problem with stripboard. Initially, it is probably best to take the easier option and build projects based on custom printed circuit boards.

Soldering on

Whatever type of circuit board is used, it will be necessary to master the art of soldering. A small and inexpensive iron with a rating of about 15W to 20W is sufficient, and it should be fitted with a small bit of about 2.5mm in diameter. The iron should have a proper stand that will hold it safely while it is hot, and act as a heatsink to prevent it from overheating. It is sometimes possible to obtain a soldering kit that includes an iron, a matching stand, and some solder of the appropriate type for project construction.

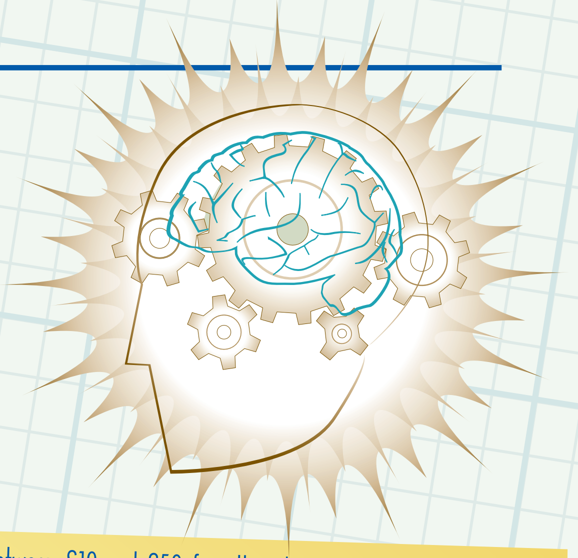
Checkout Alan Winstanley's widely acclaimed Soldering Guide at www.epemag.wimborne.co.uk/solderfaq.htm

all the hard wiring. Use a thin insulated multicore wire and not a single-core type. 7/0.2 (seven cores of 0.2mm wire) is suitable for most connections, but a heavier type such as 16/0.2 might be needed where relatively high currents are involved.

There is a strong temptation to switch on a newly constructed project and try it out as soon as it is finished. However, even if you have checked and double-checked everything along the way, it is still a good idea to thoroughly check the completed unit once more for any errors. The unit will probably work first time, but do not panic if it fails to operate properly. The problem will almost certainly be due to a minor error somewhere, and checking everything again will probably sort things out. You can then start thinking about your next project!

Ingenuity Unlimited

Our regular round-up of readers' own circuits



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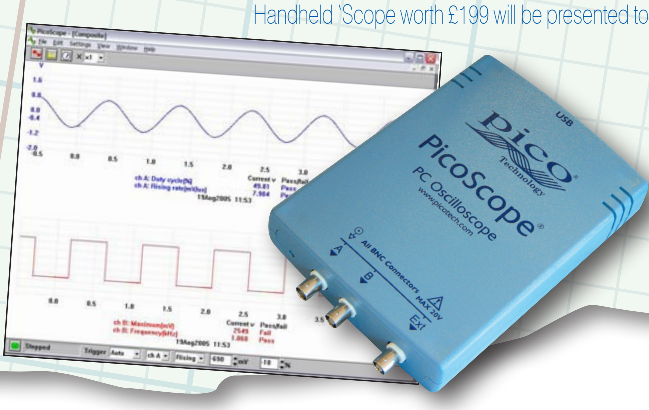

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Clock Generator – *Time Out*

THIS circuit is a one-shot/continuous clock generator that is useful as a piece of test kit when developing and testing logic circuits. It is especially useful for those who do not have access to a commercial signal generator.

At the heart of the circuit (Fig.1) is a 7555 CMOS timer IC. With switch S1 in position 1, the timer is in its continuous mode. This makes use of a less commonly seen astable configuration, where the timing capacitor C4 is charged by the same resistance that it is discharged by, this resistance being connected between the output (pin 3) and the trigger input (pin 2). Using this astable configuration gives the advantage of allowing the timer to be switched between its astable and monostable (continuous and one-shot) configurations, simply by using a single DPDT switch.

With switch S1 in position 2, the timer is in its one-shot mode and the same capacitor (C4), is again used for timing, but in this mode a different resistance is switched in for monostable timing. The one-shot can be triggered by pressing S2, a normally-open momentary action switch. Capacitor C3 and resistor R2 create a differentiator, acting to produce a narrow trigger pulse. When S2 is released, R1 acts as a pull-up resistor and it also acts in conjunction with C2 to debounce switch S2.

The timing for continuous and one-shot modes can be changed by adjusting potentiometers VR1 and VR2 respectively.

With the comonent values shown and an unloaded output, the astable frequency can be adjusted from about 0.7Hz up to about 125Hz. The duty cycle is close to 50%. The monostable pulse-width can be adjusted from about 8ms up to about 1.5 seconds.

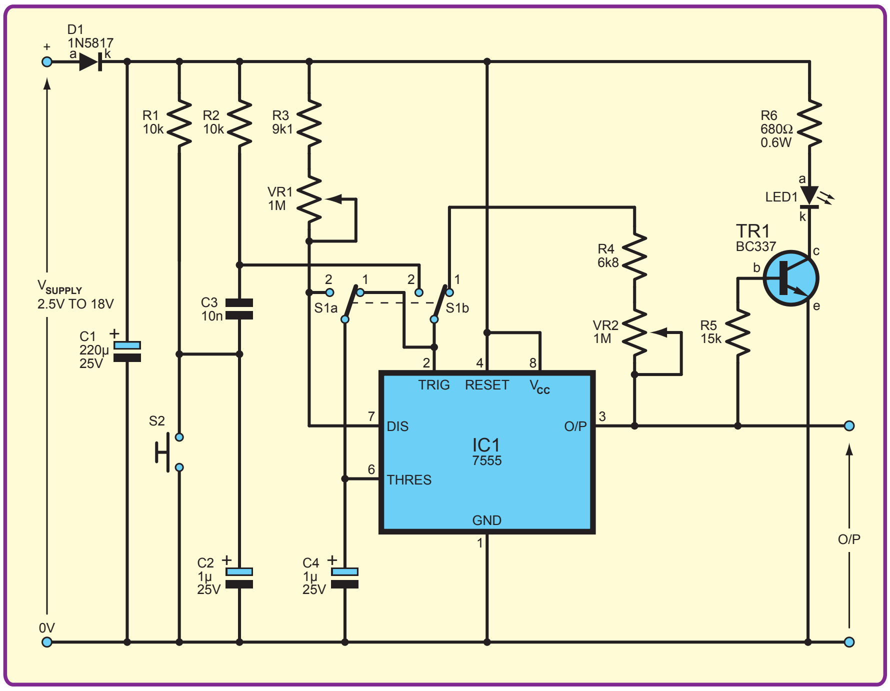

Fig.1. Complete circuit diagram for the Clock Generator

The output is both TTL and CMOS compatible. The circuit's voltage supply can range from 2.5V to 18V, and should be set to match the voltage supply to the IC(s) under test. This is because the timer's output voltage is of a similar magnitude to its supply voltage.

The timer's output drives LED1 via transistor TR1. The LED indicates output activity, but is quite dim when using a low voltage supply and is constantly lit for the higher astable frequencies. The circuit avoids driving the LED directly from the timer's output because this would load the output voltage down close to the $V_{in,high(min)}$ of some logic families.

Rogue pulses

It is worth noting that when switched to astable, the first output pulse will be slightly longer than the succeeding ones, due to the fact that C4 is starting from a totally discharged situation.

If you are unlucky with your build, you will find that an extra odd length pulse is output when switching from astable, (when the output is low), to monostable. This is caused by switch S1a leaving position 1 slightly before S1b does, causing the trigger input to be pulled low momentarily by the low output. To eliminate this minor irritation, swap S1a with S1b, keeping the same pins for positions 1 and 2.

When switching from astable, (when the output is high), to monostable, the last pulse will be shortened or lengthened. This is because this pulse is finished off using the monostable timing resistance.

Chris Hinchcliffe, Dorset

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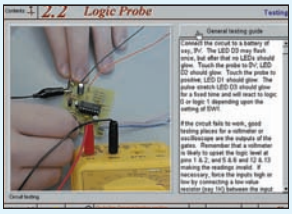
ELECTRONICS CD-ROMS

ELECTRONICS PROJECTS

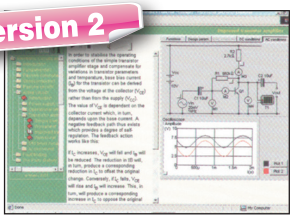

Logic Probe testing

Electronic Projects is split into two main sections: **Building Electronic Projects** contains comprehensive information about the components, tools and techniques used in developing projects from initial concept through to final circuit board production. Extensive use is made of video presentations showing soldering and construction techniques. The second section contains a set of ten projects for students to build, ranging from simple sensor circuits through to power amplifiers. A shareware version of Matrix's CADPACK **schematic capture, circuit simulation** and **p.c.b. design** software is included.

The projects on the CD-ROM are: Logic Probe; Light, Heat and Moisture Sensor; NE555 Timer; Egg Timer; Dice Machine; Bike Alarm; Stereo Mixer; Power Amplifier; Sound Activated Switch; Reaction Tester. Full parts lists, schematics and p.c.b. layouts are included on the CD-ROM.

ELECTRONIC CIRCUITS & COMPONENTS V2.0

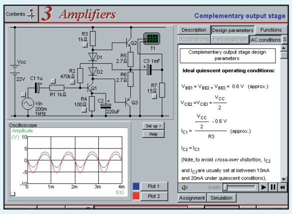
Version 2


Circuit simulation screen

Electronics Circuits & Components V2.0 provides an introduction to the principles and application of the most common types of electronic components and shows how they are used to form complete circuits. The virtual laboratories, worked examples and pre-designed circuits allow students to learn, experiment and check their understanding. Version 2 has been considerably expanded in almost every area following a review of major syllabuses (GCSE, GNVQ, A level and HNC). It also contains both European and American circuit symbols. Sections include: ***Fundamentals***: units and multiples, electricity, electric circuits, alternating circuits. ***Passive Components***: resistors, capacitors, inductors, transformers. ***Semiconductors***: diodes, transistors, op amps, logic gates. ***Passive Circuits. Active Circuits***. *The Parts Gallery* will help students to recognise common electronic components and their corresponding symbols in circuit diagrams.

Included in the Institutional Versions are multiple choice questions, exam style questions, fault finding virtual laboratories and investigations/worksheets.

ANALOGUE ELECTRONICS

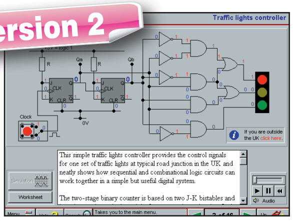

Complimentary output stage

Analogue Electronics is a complete learning resource for this most difficult branch of electronics. The CD-ROM includes a host of virtual laboratories, animations, diagrams, photographs and text as well as a SPICE electronic circuit simulator with over 50 pre-designed circuits.

Sections on the CD-ROM include: ***Fundamentals*** – Analogue Signals (5 sections),Transistors (4 sections), Waveshaping Circuits (6 sections). ***Op Amps*** – 17 sections covering everything from Symbols and Signal Connections to Differentiators. ***Amplifiers*** – Single Stage Amplifiers (8 sections), Multi-stage Amplifiers (3 sections). ***Filters*** – Passive Filters (10 sections), Phase Shifting Networks (4 sections), Active Filters (6 sections). ***Oscillators*** – 6 sections from Positive Feedback to Crystal Oscillators. ***Systems*** – 12 sections from Audio Pre-Amplifiers to 8-Bit ADC plus a gallery showing representative p.c.b. photos.

DIGITAL ELECTRONICS V2.0

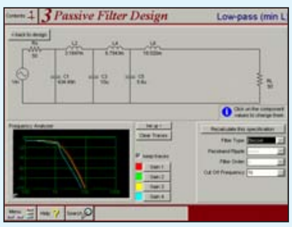
Version 2


Virtual laboratory - Traffic Lights

Digital Electronics builds on the knowledge of logic gates covered in *Electronic Circuits & Components* (above), and takes users through the subject of digital electronics up to the operation and architecture of microprocessors. The virtual laboratories allow users to operate many circuits on screen.

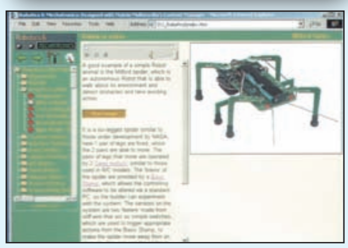
Covers binary and hexadecimal numbering systems, ASCII, basic logic gates, monostable action and circuits, and bistables – including JK and D-type flip-flops. Multiple gate circuits, equivalent logic functions and specialised logic functions. Introduces sequential logic including clocks and clock circuitry, counters, binary coded decimal and shift registers. A/D and D/A converters, traffic light controllers, memories and microprocessors – architecture, bus systems and their arithmetic logic units. Sections on Boolean Logic and Venn diagrams, displays and chip types have been expanded in Version 2 and new sections include shift registers, digital fault finding, programmable logic controllers, and microcontrollers and microprocessors. The Institutional versions now also include several types of assessment for supervisors, including worksheets, multiple choice tests, fault finding exercises and examination questions.

ANALOGUE FILTERS


Filter synthesis

Analogue Filters is a complete course in designing active and passive filters that makes use of highly interactive virtual laboratories and simulations to explain how filters are designed. It is split into five chapters: **Revision** which provides underpinning knowledge required for those who need to design filters. **Filter Basics** which is a course in terminology and filter characterization, important classes of filter, filter order, filter impedance and impedance matching, and effects of different filter types. **Advanced Theory** which covers the use of filter tables, mathematics behind filter design, and an explanation of the design of active filters. **Passive Filter Design** which includes an expert system and filter synthesis tool for the design of low-pass, high-pass, band-pass, and band-stop Bessel, Butterworth and Chebyshev ladder filters. **Active Filter Design** which includes an expert system and filter synthesis tool for the design of low-pass, high-pass, band-pass, and band-stop Bessel, Butterworth and Chebyshev op.amp filters. This CD-ROM is being discontinued, **only the Hobbyist/Student version is now available**.

ROBOTICS & MECHATRONICS


Case study of the Milford Instruments Spider

Robotics and Mechatronics is designed to enable hobbyists/students with little previous experience of electronics to design and build electromechanical systems. The CD-ROM deals with all aspects of robotics from the control systems used, the transducers available, motors/actuators and the circuits to drive them. Case study material (including the NASA Mars Rover, the Milford Spider and the Furby) is used to show how practical robotic systems are designed. The result is a highly stimulating resource that will make learning, and building robotics and mechatronic systems easier. The Institutional versions have additional worksheets and multiple choice questions.

- Interactive Virtual Laboratories
- Little previous knowledge required
- Mathematics is kept to a minimum and all calculations are explained
- Clear circuit simulations

PRICES

Prices for each of the CD-ROMs above are:

(Order form on third page)

Hobbyist/Student	**£45**	**inc VAT**
Institutional (Schools/HE/FE/Industry)	**£99**	**plus VAT**
Institutional 10 user (Network Licence)	**£249**	**plus VAT**
Site licence	**£499**	**plus VAT**

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PICmicro TUTORIALS AND PROGRAMMING

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Suitable for use with the three software packages listed below.

This flexible development board allows students to learn both how to program PICmicro microcontrollers as well as program a range of 8, 18, 28 and 40-pin devices from the 12, 16 and 18 series PICmicro ranges. For experienced programmers all programming software is included in the PPP utility that comes with the development board. For those who want to learn, choose one or all of the packages below to use with the Development Board.

- Makes it easier to develop PICmicro projects
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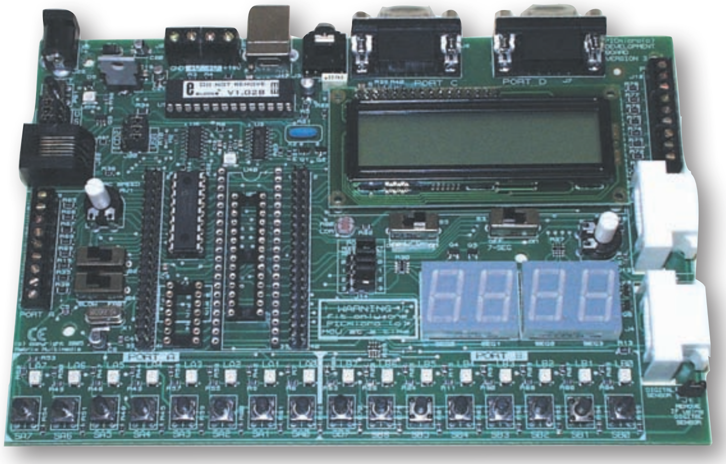


£158 including VAT and postage, supplied with USB cable and programming software

SOFTWARE

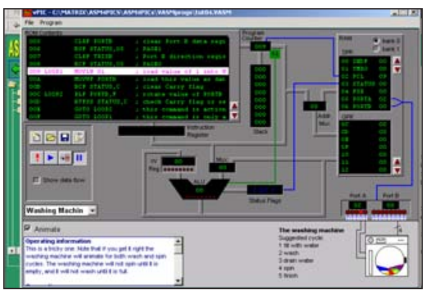
ASSEMBLY FOR PICmicro V3

(Formerly PICtutor)

Assembly for PICmicro microcontrollers V3.0 (previously known as PICtutor) by John Becker contains a complete course in programming the PIC16F84 PICmicro microcontroller from Arizona Microchip. It starts with fundamental concepts and extends up to complex programs including watchdog timers, interrupts and sleep modes.

The CD makes use of the latest simulation techniques which provide a superb tool for learning: the Virtual PICmicro microcontroller, this is a simulation tool that allows users to write and execute MPASM assembler code for the PIC16F84 microcontroller on-screen. Using this you can actually see what happens inside the PICmicro MCU as each instruction is executed, which enhances understanding.

● Comprehensive instruction through 45 tutorial sections ● Includes Vlab, a Virtual PICmicro microcontroller: a fully functioning simulator ● Tests, exercises and projects covering a wide range of PICmicro MCU applications ● Includes MPLAB assembler ● Visual representation of a PICmicro showing architecture and functions ● Expert system for code entry helps first time users ● Shows data flow and fetch execute cycle and has challenges (washing machine, lift, crossroads etc.) ● Imports MPASM files.

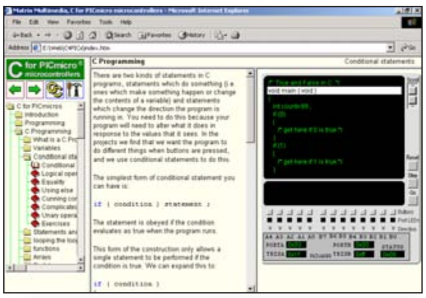


'C' FOR 16 Series PICmicro Version 4

The C for PICmicro microcontrollers CD-ROM is designed for students and professionals who need to learn how to program embedded microcontrollers in C. The CD-ROM contains a course as well as all the software tools needed to create Hex code for a wide range of PICmicro devices – including a full C compiler for a wide range of PICmicro devices.

Although the course focuses on the use of the PICmicro microcontrollers, this CD-ROM will provide a good grounding in C programming for any microcontroller.

● Complete course in C as well as C programming for PICmicro microcontrollers ● Highly interactive course ● Virtual C PICmicro improves understanding ● Includes a C compiler for a wide range of PICmicro devices ● Includes full Integrated Development Environment ● Includes MPLAB software ● Compatible with most PICmicro programmers ● Includes a compiler for all the PICmicro devices.



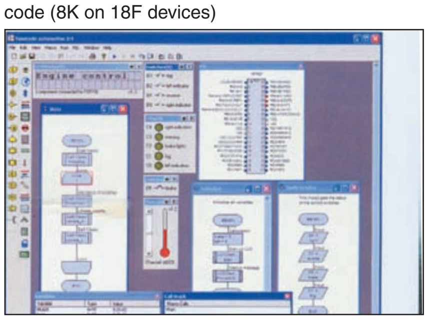
Minimum system requirements for these items: Pentium PC running, 2000, ME, XP; CD-ROM drive; 64MB RAM; 10MB hard disk space.
Flowcode will run on XP or later operating systems

FLOWCODE FOR PICmicro V4

Flowcode is a very high level language programming system based on flowcharts. Flowcode allows you to design and simulate complex systems in a matter of minutes. A powerful language that uses macros to facilitate the control of devices like 7-segment displays, motor controllers and LCDs. The use of macros allows you to control these devices without getting bogged down in understanding the programming. When used in conjunction with the Version 3 development board this provides a seamless solution that allows you to program chips in minutes.

- Requires no programming experience
- Allows complex PICmicro applications to be designed quickly
- Uses international standard flow chart symbols
- Full on-screen simulation allows debugging and speeds up the development process.
- Facilitates learning via a full suite of demonstration tutorials
- Produces ASM code for a range of 18, 28 and 40-pin devices
- 16-bit arithmetic strings and string manipulation
- Pulse width modulation
- I2C.

New features of Version 4 include panel creator, in circuit debug, virtual networks, C code customisation, floating point and new components. The Hobbyist/Student version is limited to 4K of code (8K on 18F devices)



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Institutional/Professional 10 user (Network Licence)	£350	plus VAT
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Flowcode Institutional (Schools/HE/FE/Industry)	£149	plus VAT
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TINA Design Suite is a powerful yet affordable software package for analysing, designing and real time testing analogue, digital, MCU, and mixed electronic circuits and their PCB layouts. You can also analyse RF, communication, optoelectronic circuits, test and debug microcontroller applications.

Enter any circuit (up to 100 nodes) within minutes with TINA's easy-to-use schematic editor. Enhance your schematics by adding text and graphics. Choose components from the large library containing more than 10,000 manufacturer models. Analyse your circuit through more than 20 different analysis modes or with 10 high tech virtual instruments. Present your results in TINA's sophisticated diagram windows, on virtual instruments, or in the live interactive mode where you can even edit your circuit during operation.

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***Flowcode V3** (Hobbyist/Student) – For details on Flowcode, see the previous page.*

This offer gives you two seperate CD-ROMs – the software will need registering (FREE) with Designsoft (TINA) and Matrix Multimedia (Flowcode), details are given within the packages.

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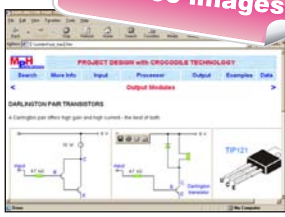

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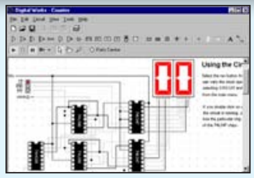
Minimum system requirements for these CD-ROMs: Pentium PC, CD-ROM drive, 32MB RAM, 10MB hard disk space. Windows 2000/ME/XP, mouse, sound card, web browser.

DIGITAL WORKS 3.0



Counter project

Digital Works Version 3.0 is a graphical design tool that enables you to construct digital logic circuits and analyze their behaviour. It is so simple to use that it will take you less than 10 minutes to make your first digital design. It is so powerful that you will never outgrow its capability ● Software for simulating digital logic circuits ● Create your own macros – highly scalable ● Create your own circuits, components, and i.c.s ● Easy-to-use digital interface ● Animation brings circuits to life ● Vast library of logic macros and 74 series i.c.s with data sheets ● Powerful tool for designing and learning.

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Max's Cool Beans

By Max The Magnificent

So much to do, so little time...

I don't know about you, but my days are full to bursting with 'stuff' to do. In the last couple of weeks as I pen these words, for example, I've presented to NASA and been involved in an on-stage debate at the *Embedded Systems Conference (ESC)* in Silicon Valley.

NASA and the JPL

First, I flew out to the Jet Propulsion Laboratory (JPL) in Pasadena, California, to give a presentation to a bunch of NASA/JPL folks about the state-of-the-art in FPGA technologies, including devices and design and verification tools.

As soon as I'd been checked in through security at JPL (which was about five minutes before I somehow managed to lose my security badge), the first thing I saw was a picture of myself plastered on a video screen accompanying an announcement of my talk. (My mother will 'dine out' at her hairdressers for weeks on this.)

Truth to tell, I was a wee bit nervous about giving this talk because the folks at JPL are all super-clever and you always worry that you are going to make a bosh of the whole thing. In the event, however, my presentation seemed to go down rather well, and it's spawned some interesting projects that I will discuss in a future column.

Following my talk, the folks at the JPL were kind enough to give me a guided tour, and I got to see all sorts of mega-cool things, such as the laboratory in which they are assembling and testing the next-generation Mars Rover.

Compared to previous rovers, this one is going to be a monster (about the size of a small car). This means that they can't land it the way they did the previous rovers (surrounding them in balloons and bouncing them along the surface of Mars until they come to a halt). So they showed me a simulation of the solution they've decided upon.

The idea is that everything is packed in a large capsule that hurls in through the atmosphere. Once things have slowed down sufficiently, the heat shield is dumped and a parachute is deployed. This is where things start to get really interesting. As the capsule nears the ground the parachute is discarded and a rocket system fires up. The rocket flies around until it decides on the best landing location, and then the rover is lowered to the ground on cables with the rocket still firing. Once the rover is on the ground, the cables disengage and the rocket flies off and lands itself somewhere close by.

The Embedded conference

This year is turning out to be a big one for yours truly with regard to the *Embedded Systems Conference (ESC)*. Actually, this is a series of conferences. The one I just attended was in Silicon Valley. There's another one in Bangalore, India, in July (I'll be presenting a couple of papers there), yet another one later on in the year in Boston, and quite possibly others of which I'm not currently aware.

There were a couple of items of interest to me personally with regard to *ESC* Silicon Valley. First, the keynote presentation was given by Dr Michio Kaku, who is a theoretical physicist specialising in string field theory (this is like string theory, but more complicated). Dr Kaku is also a futurologist, an author, and a radio and TV personality who is incredibly good at explaining science to the masses in general, and to me in particular.

After Dr Kaku's very amusing and interesting presentation, I was fortunate enough to be taken backstage to meet the man himself. In fact, I gave him an autographed copy of my book *Bebop to the Boolean Boogie* (*An Unconventional Guide to Electronics*). He told me that he was sure he would enjoy reading it and I replied that I would be asking him questions later (I wonder if he did actually read it).

In addition to numerous meetings with various companies in which I saw next-generation technology demonstrations that made me squeal like a schoolgirl, I also took part in a live debate with microprocessor expert Jim Turley. This turned out to be a very popular event – the ESC Theatre was packed, and it was standing room only at the back (admittedly it wasn't a very big Theatre, but still...).

To be honest, I was a little nervous by the start of the debate. This was largely due to the fact that folks had been coming up to me all day assuring me that they were planning on attending, and telling me things about Jim like: 'He's incredibly clever' and 'He's a great speaker' and 'He's really very funny' ... and then they would pat me on the shoulder and say something like: 'Of course, you're very good as well, Max' (in an unconvincing sort of way).

Jim was arguing that if you are building an embedded system, your best option is to use an off-the-shelf microcontroller. By comparison, my position was that a large proportion of today's embedded systems include a field-programmable gate array (FPGA), in which case you are better of using some of the FPGA fabric to implement your microcontroller. The debate swung back and forth, with points being scored on both sides, but I held my own and – in fact – I actually think that I may have come out on top.

It doesn't slow down

I wish I had a *Dr Who* TARDIS so that I could go away for a month to catch up (taking only a few minutes in elapsed time here in my office). But of course, there's no such luck, so now I'm back in the fray desperately trying to keep my nose above the water line. In addition to real work (ugh), I now have only a little over a week to create my slides and associated papers for ESC India and send them off to the folks in charge. (Although the conference isn't until July, they need the slides and papers early so as to add them into the conference proceedings.)

I'll be giving two presentations – the shorter one will be only 75 minutes, but the longer one is a full-day affair, in which I'll be speaking for over five hours. The result is that I'm going to require several hundred slides. And the real problem is that I only actually started work on this a few evenings ago (there's no time to do it in the day), so the sands of time are really starting to race through the cosmic hourglass. I'm too young for all of this... Stop the world, I want to get off! Oh well, until next time, have a good one!

Check out 'The Cool Beans Blog' at www.epemag.com

Catch up with Max and his up-to-date topical discussions

READOUT

Email: editorial@wimborne.co.uk

Matt Pulzer addresses some of the general points readers have raised. Have you anything interesting to say? Drop us a line!

All letters quoted here have previously been replied to directly

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☆ LETTER OF THE MONTH ☆

Hells Bells and Decibels!

Dear Editor

Congratulations to Ian Bell on yet another terrifically informative article, *'Hells Bells and Decibels'* (*EPE* May 2010), in his excellent *Circuit Surgery* series.

There are, however, I think, a couple of small errors in the penultimate paragraph of this article. In this paragraph, Ian calculates a value, in dBu, equal to the level of the dBV reference level, (1 volt), but calculated with respect to the dBu reference level (0.775V). Ian writes, '1dBV is equal to 2.2dBu'. This should actually read '0dBV is equal to 2.2dBu.' This is because 0dBV (and not 1dBV) is equal to 1V, which is the voltage level that, in this case, is being compared to the reference level of 0.775V (0dBu), leading to the equation 20 * log10(1/0.775) which gives a result of 2.2dBu. Actually, 1dBV = 1.122V = 3.2dBu, but this is an arbitrary signal level of no particular significance. Similarly, later in the same paragraph, '1dBu is equal to –2.2dBV' should, by similar reasoning, actually read '0dBu is equal to –2.2dBV.'

These are only minor errors when compared to the amount of technically accurate information in Ian's article, but I feel it is worth clarifying the issue, as it could be potentially quite confusing for an electronics enthusiast who is trying to get to grips with the concepts of dBu, dBV etc, which can be confusing enough when you first start trying to understand them!

It may be the case that these errors have been carried over from the *EPE* March 09 *Circuit Surgery* article, entitled Interconnecting Audio Equipment, which states the same equivalences.

Chris Hinchcliffe, Dorset, by email

Ian Bell replies... Thanks Chris, for pointing out this error, and for your positive comments about Circuit Surgery.

Interestingly, this error is widespread and appears in what should be reliable sources. After only a quick Internet search, I found two instruction manuals for profession audio equipment with the statement '1dBV equals +2.2dBu'.

Converting from dBu to dBV is straightforward; just subtract 2.218 from the dBu value. Similarly, add 2.218 to a dBV value to get the dBu equivalent.

Giving cold callers the cold shoulder

Dear Editor

I would like to offer a project suggestion for one of your readers or a commercial company.

I am an OAP, and I'm having a lot of trouble from 'cold calling' telephone calls (especially international ones). This is very annoying if callers ring when I am having an afternoon snooze; by the time I get to the phone it has gone off. The caller display usually says 'international call' or 'number withheld'. I have contacted British Telecom and registered for caller preference to stop cold calling, but they say they cannot stop international calls.

It should be possible to make a device to stop all calls ringing unless the number is listed on a personal call list, in which case the call would be passed through to ring as usual. If the number is not on the list, then it should be diverted to a telephone answer machine with no external ringing. The machine could say, 'This is a possible nuisance call filtering machine. Please leave your name and number and I will call back.' If you ring back and the original call was genuine, then the number could be added to your personal list for future use. If no number is left, then the nuisance is solved.

There should also be a button to delete a number from your personal list if it is no longer required. It would be useful if the machine could take SIM cards, thereby saving a lot of retyping of a mobile phone list.

While it may take some time to enter all acceptable numbers, it would be time well spent if it cuts out all the nuisance calls. I feel there could be a big market for such a device.

John Eley, Glenfield, Leics

I'm sure there is a fortune out there for the right design that screens out these pests – see the TrueCall unit available from Amazon for around £80. I've lost count of the number of times I've been offered the chance to clear my credit cards or take advantage of a unique opportunity to… what a waste of time.

Software annotation and explanation

Dear Editor

As someone who once programmed for a living, I can say with some authority that one of the best ways to learn programming is to systematically work through someone else's documented code.

Now that so many designs incorporate PIC processors, and you have articles on how to program PICs, isn't it a pity that a design such as the *High-Accuracy Digital LC Meter (Mar '10)* provides downloadable code, but not a run through of the code that is inherent to the function of this device.

I would argue that in the case of a hybrid piece of hardware and software, it is meaningless to discuss the components of the circuit design unless you are also willing to go through the software programme.

Conversely, if you are willing to treat the software as a 'black box', why bother to describe the circuit? Why not just say, 'buy this kit, be careful that you solder the right components in the right place in the right orientation, and it should just work'.

To examine the circuit diagram implies that the reader wishes to understand it, perhaps with a view to designing hardware for him/herself. Unless s/he understands how to program, options will be limited.

Please consider providing at least an annotated listing with perhaps a flowchart and verbal description of the major control and decision points in the code.

It would be a major benefit to build something like this and then be able to understand what is happening inside the controller.

I realise the example that I mentioned may be a special case, where references are given to the originators of the code, but I meant to make a general point for all big projects like it.

Brian Williams, by email

Brian, you make a good point and, ideally, if we had space we would give greater prominence to the software side of projects. Unfortunately, the complexity and size of many of the programs built into projects mean that space restrictions do seriously limit what is possible in a printed magazine.

We do have the 'unlimited' space of the Internet, and we will seriously consider your suggestion, at least for home-grown projects. However, we are not always able to publish documented code, as many contributors wish to protect their work from commercial exploitation.

Of course, we do cover software and programming elsewhere in EPE*, and work hard to teach techniques and skills, particularly with respect to PICs.*

When it comes to descriptions of the circuit, we give quite detailed explanations of operation, and I hope that rather than viewing the PIC as a 'black box' readers do understand that these devices are interfaced in a particular way and that the software performs tasks in a particular order and in a certain timeframe – perhaps a 'grey box'?!

I appreciate your observation, and where possible I will encourage authors to at least provide a flow chart and/or a bird's-eye-view annotation of relevant code.

Cheap routers

Dear Editor

I was glad to read, in April's *Net Work* column that Alan resolved his WLAN problems. I too have experienced cheap routers having a tendency to die after a couple of years in service – sometimes less.

I believe that as the devices are intended for home use, the manufacturers can make them cheaper by designing them on the assumption that they will not be kept powered up and running continuously from the day that they are bought. In contrast, more expensive commercial routers are designed to be always-on units, and so more attention is paid to factors like heat dissipation and component quality.

There is, however, a happy medium. I have a Linksys WRT54G at home that has been powered up and under fairly heavy load for nearly six years, with only the occasional weekend power down when the house is empty and maybe a week in the summer. So far, the only sign of wear is some discolouring of the PSU label from the constant heat. I guess the PSU may go one day, but it's a standard power connector, so not hard to replace.

The WRT54G is an excellent router, but it lacks an ADSL modem. When I moved to a non-cable area just over three years ago, this became a problem. The only decent router I could find that supported ADSL2+ was the Netgear DG834G, and I have to say, this is also an excellent router and has been in constant use for almost three years (with the Linksys one still in service elsewhere).

The moral of the story is that you get what you pay for. Netgear and Linksys (a Cisco company) both make quality products for a reasonable price. Alan is right when he says you could pay up to £70 for one of these, but they can be found for much less, and when you consider they are far less likely to 'go pop' a year after the warranty expires, they work out good value.

Both of the mentioned routers have custom firmware available from the 'Open Source' community, which allows the more experimentally inclined to put them to some very imaginative uses.

Finally, could I beg anyone considering using mains-borne networking devices to visit **www.rsgb.org/plt**. These devices work by injecting RF into the mains wiring in your house, effectively turning it into a large antenna.

This wasn't a problem once upon-a-time, when projects in magazines like *EPE* let you send a few bytes of information down the mains, but in order to get the tens of megabytes per second of data throughput that the market now demands, a very wideband RF signal is required, which inevitably interferes with the reception of weak or distant radio signals and threatens hobbies like short wave listening and amateur radio, as well as many, more important uses of our radio spectrum.

Simon Alderson, by email

PS. I picked up *EPE* for the first time in a couple of years after being reminded of it while searching out the link for Alan's excellent soldering tutorial for a friend. It was great to see lots of interesting projects in recent issues, well done team. I think I might have to re-subscribe again...

Alan Winstanley replies… Many thanks for your comments and interest in Net Work.

Simon makes a valid point – consumer-grade routers (like most equipment these days) are made very much to a price, which shows in the number of hardware failures that I have seen, especially of plug-in switched-mode power supplies. I am quite alarmed sometimes by the temperature that routers reach during operation, and I view the meagre ventilation slots with suspicion. Thermal cyclical stresses affect reliability, so turning them on and off can reduce their life, but like you, I'm not convinced these devices are designed with always-on operation in mind.

It's certainly wise to shop around when sourcing new peripherals. The point I made in April's Net Work *was that less well known makes, such as the Tenda W300D cost typically half the retail price of shrink-wrapped brands, but they needn't be ruled out merely because of their lower brand awareness.*

Actually, I started my broadband life with a Linksys WRT54G stacked with a matching hub. I was impressed with its robustness, but various network issues arose after a while. A replacement Belkin WiFi router finished its life being powered from a spare PSU from Maplin before developing the ADSL fault I described in Net Work. *The latest Tenda is humming away on the desk as I type: there is plenty to like about it, and if it only lasts a couple of years I won't mind due to the low price.*

Thank you also for reminding us that router firmware can be flash-upgraded by visiting the maker's website; but do remember that open-source flash upgrades should be chosen with great care.

USB power supply for hard drives

Dear Editor

The backed-up data on the external hard drive (as powered by the *USB Power Injector* circuit in the April '10 article) is presumably valuable or even irreplaceable. For the sake of a few extra cheap components, I'd protect the drive by a crowbar over-voltage limiter on the output of the supply. When the output volts exceed a threshold, a thyristor fires and blows the preceding fuse, shorting the power input to the hard drive in 'semiconductor time.'

Should the mains 'plugpack' supply fail, it could easily put a high voltage on the regulator in your circuit, exceeding its limits and causing it to go open-circuit.

As I often remind naive computer users, the hardware is replaceable. The data isn't – and is, hence, the most valuable part of your system.

Godfrey Manning,
Edgware, by email

Wise words Godfrey – reminds me of a good piece of advice I was once given: 'There are only two kinds of hard drive; ones that have failed, and ones that are going to fail!' Keep that in mind and take appropriate precautions with irreplaceable data

Desoldering advice

Dear Editor

I particularly enjoy Julian Edgars' *Recycle It!* feature. There is something very satisfying in rescuing usable bits 'n' bobs from something that would ordinarily be sent to a rubbish dump.

I was recently given a malfunctioning PC printer, from which I extracted the stepper motors, switches and various connectors. Understanding how to use the switch-mode power supply was beyond me, so I resorted to removing the large capacitors and dismantling the small transformers for the enamelled copper wire – good for experimenting with home made electric motors!

There were other useful components on the circuit board, but even after years of handling a soldering iron I've always found desoldering difficult. Any chance of an article on desoldering methods? I'm sure you and your team have learned many ways to do this.

Thanks for a great magazine.

Simon Moore

Your wish is not only our command, but has been anticipated and met in full! Please see EPE *online editor Alan Winstanley's excellent soldering (and desoldering) guide at:* ***www.epemag.wimborne.co.uk/solderfaq.htm****.*

Net Work

Alan Winstanley

A 3D view

Last month, I highlighted how Google Street View had soft-launched the remaining map coverage of the UK and other countries, making it possible to take a motorist's view of most of Britain's towns and 238,000 miles of trunk roads and country lanes. I showed a typical Street View scene with a car and caravan parked in the front yard of a home: the licence plate was clearly visible along with some items that might attract caravan thieves or inquisitive burglars. I duly 'reported a privacy problem' and succeeded in having the number plate blurred, but Google's reporting criteria means that only the householders themselves could tackle Google if the rest of their privacy was being compromised.

Just before my column went to press last month, the 3D Google Street View option had been withdrawn. Happily it has now been restored – just press 'T' on your keyboard to toggle 3D mode, or right-click on a Street View scene and choose 3D mode. Plastic 3D glasses can be bought from eBay for just a few pounds, but the effect is very modest.

If you would like to explore the world of 3D images, then sporting your 3D glasses, websites such as SkyTopia.com offer a freeware Windows program (untested by the writer) to create anaglyphs at: **www.skytopia.com/software/stereoptica/**. YouTube also has many 3D anaglyph tutorials and videos, and **http://en.wikipedia.org/wiki/Anaglyph_image** has more background information and history for anyone interested.

Google is an incurable advertising junkie, and it probably won't be long before advertisements pop up on your Google Navigation display or (heaven forbid) speak to you, imploring you to divert into a nearby pizzeria – maybe the canny pizzeria owner will have bid more to win a higher ad placement than the nearby fish and chip shop in Google's advertising rankings.

The biggest attraction of Google Navigation is, of course, that it's free, unlike satnav systems such as TomTom, which lock their users into buying updates: a new TomTom map today is £40 ($60) or you can subscribe to updates at about £20 ($30) per year. Speed camera and traffic updates add £30 ($45) to the annual bill.

I can't decide which will be better for the driver or biker. It remains to be seen how frequently Google's maps and street views will be updated, and there is still something to be said for pre-loading an entire map into a TomTom 'at leisure' and tracking your position using GPS, rather than hoping Google Navigation can stream tons of live data via a mobile GPRS/3G connection while on the move. Mobile Internet data is still a problem; I can drive for 10 or 15 miles without a TomTom traffic update because there is no signal available for my HTC mobile (which refreshes the TomTom wirelessly via Bluetooth). As network coverage improves this disparity will vanish, but I would not write off a self-contained satnav just yet.

The sound of beating TomToms

Google hasn't finished with us yet: back in the May issue I touched on the likelihood of in-car/on-bike satellite navigation based on Google Maps and Street View, and Google Maps Navigation Beta has been released right on cue (as reported in last month's *Everyday News*). It integrates its search engine with Satellite view, Maps and Street View, and is designed for Google's Android-based mobile phones with GPS. Hence, you need a data tariff (GPRS, 3G) to download data or maps from the Internet while on the move, so it is only usable when there is a suitable signal. A demo of Google Navigation on YouTube is at: **www.youtube.com/watch?v=tGXK4jKN_jY**.

Google's search algorithms come into their own when inputting waypoints: instead of laboriously typing a specific address (eg National Exhibition Centre, Birmingham) you could 'navigate to the In-Focus photography exhibition in Birmingham' and Google Navigation will figure out the rest. You can search by name – just speak or type in a business and Google Maps Navigation will, hopefully, find it and navigate there (hence the importance of businesses being listed in Google Local Business Centre). In the US, Google already offers live traffic flow data in selected cities, and it seems inevitable that they will do the same in the UK. They promise green, yellow or red routes that reflect the traffic congestion ahead.

A 3D Google Street View anaglyph of a Heroes & Villains Party held at a Shetlands Island pub. (Courtesy streetviewsightings.co.uk)

Google Navigation will superimpose your route onto Street View in real time – if your Android mobile phone can receive an adequate data signal

Too much information

For many travellers, Google Navigation will probably be the perfect solution, and Google's advertisers will ultimately agree. This technology is a prime example of 'disruptive innovation', the term coined by Clayton Christensen (see **www.claytonchristensen.com/disruptive_innovation.html**) to describe any technology that finds favour with users who are currently frustrated by a market's existing offerings. The 'new' upstart then evolves until current market players (present-day satnav suppliers) must either adapt or be squeezed out of existence. Digital cameras are a perfect example of how disruptive technology destroyed the 35mm camera market. TomTom has never stood still though, so an interesting technological battle is about to get under way.

While Google can place ever more free data at our disposal, it may become bloated by more options and advertising 'noise' as time goes by. Google Navigation will undoubtedly disrupt and eventually polarise the market between those running Google apps on an Android or iPhone, or those preferring to subscribe to a fully supported, paid-for satnav unit instead. – You know, a proper satnav.

You can Email the author at: **alan@epemag.demon.co.uk** or share your views with the Editor at: **editorial@epemag.wimborne.co.uk**.

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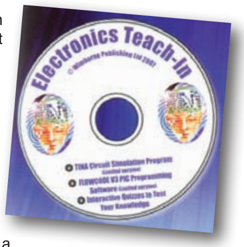
Electronics Teach-In CD-ROM

Mike Tooley



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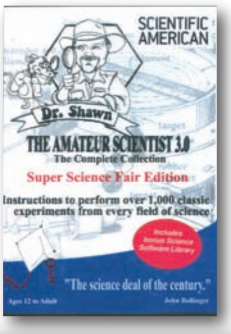

PROJECT CONSTRUCTION

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RADIO

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I. D. Poole

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Topics covered include: The equipment that is needed; Setting up the shack; Which aerials to use; Methods of construction; Preparing for the licence.

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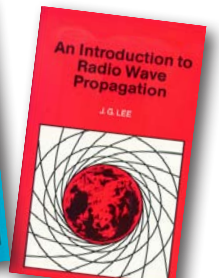

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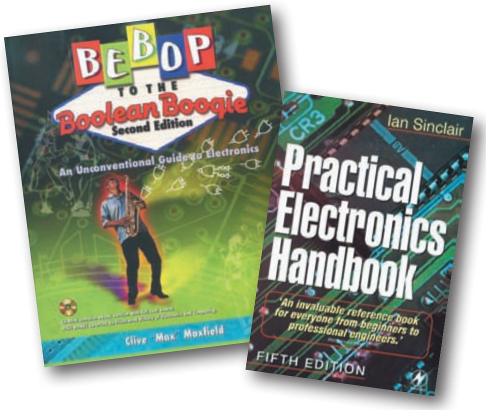

INTERFACING PIC MICROCONTROLLERS
Martin Bates

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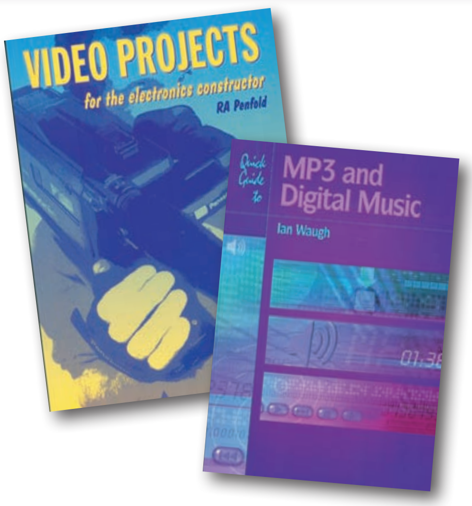

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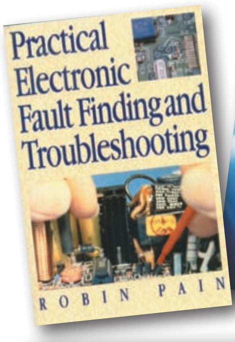

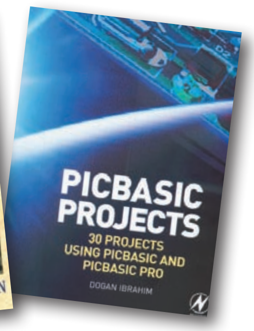

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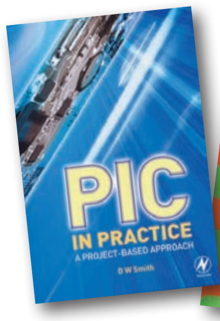

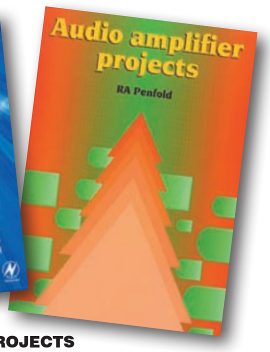

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